CA2BCU 1673T02

CA
2
CU
16
73
T02

3 1761 05689021 3

WESTWATER
RESEARCH CENTRE

Technical Report No. 2
April 1973

Earth Sciences Library

I. E. S.
JUL 13 1983
RESOURCE CENTRE

A Preliminary Water Quality Survey of the Lower Fraser River System

by

A.H. Benedict, K.J. Hall
and F.A. Koch

University of British Columbia
Vancouver 8, Canada

A Preliminary Water Quality Survey of the Lower Fraser River System

by

A.H. Benedict, K.J. Hall
and F.A. Koch

Westwater Research Centre
University of British Columbia
Vancouver 8, Canada

Technical Report No. 2

This study is part of an interdisciplinary investigation of water quality in the Lower Fraser River. It was conducted by Assistant Professor A.H. Benedict and Assistant Professor K.J. Hall, both of the Department of Civil Engineering at the University of British Columbia, and F.A. Koch of the Westwater Research Centre. The Centre supported the study and the facilities of the Department of Civil Engineering and of Westwater were utilised.

TABLE OF CONTENTS

		Page
Acknowledgements		2
List of Tables and Figures		3
Summary		4
I.	Introduction	5
II.	Description of the Fraser River	6
III.	Historical Review of Water Quality Studies in the Lower Fraser River System	7
IV.	Description of the Sampling Program	19
V.	Results of Sampling Program	25
VI.	Discussion of Results	35
References		41
Bibliography		43
Appendix		44
Map		50

TABLE OF CONTENTS

	Page
Acknowledgements	2
List of Tables and Figures	3
Summary	4
I. Introduction	5
II. Description of the Fraser River	6
III. Historical Review of Water Quality Studies in the Lower Fraser River Basin System	7
IV. Description of the Sampling Program	19
V. Results of Sampling Program	23
VI. Discussion of Results	32
References	41
Bibliography	43
Appendix	44
Map	50

ACKNOWLEDGEMENTS

The authors would like to acknowledge the assistance of both the Environmental Protection Service of the Department of the Environment, and the Greater Vancouver Sewerage and Drainage District for making their data available for the historical review.

The assistance of Ms. Liza McDonald in supervising laboratory work carried out in the Pollution Control Laboratory of the Department of Civil Engineering, and the analytical work of Mr. John Hayethorne, Mr. Kauko Kaariainen, Mr. Itsuo Yesaki and Ms. Sheila Doel is greatly appreciated.

The work of Mr. Les Johnson and Prof. Lionel Coulthard of the Department of Agricultural Engineering in conducting and supervising the nutrient analyses, and the assistance of Mr. R. Leary and Dr. K. Fletcher of the Department of Geological Sciences in conducting and supervising the trace metal analyses is also greatly appreciated.

Special acknowledgement is made to Mr. Richard Brun of the Department of Civil Engineering who carried out drafting work on the tabulations and figures presented in the report.

LIST OF TABLES AND FIGURES

Table No.		Page
1	Summary of Water Quality in the Lower Fraser System Prior to 1972	12
2	Identification of Fraser River Sampling Stations	20
3	Identification of Tributary Sampling Stations	22
4	Quality Parameters Investigated during the Preliminary Sampling Program	24
5	Fraser River Water Quality	28
6	Water Quality at Tributary Sites	31
7	Fraser River Sediment Characteristics	34
8	Tributary Sediment Characteristics	34
9	Comparison of Tributary Water Quality	40

Figure No.		
1	Schematic of Fraser River and Tributary Sampling Sites	20
2	Kjeldahl Nitrogen and Volatile Content of Sediments	38

Digitized by the Internet Archive
in 2025 with funding from
University of Toronto

https://archive.org/details/31761056890213

SUMMARY

The data assembled and reviewed in this report provide an overview of existing water quality in the Lower Fraser River and its tributaries, based on available historical data and on the results of the preliminary sampling program which was conducted during the months of July and August, 1972. Comparison of this summer data with that from the historical review shows no significant difference for those parameters and reaches where comparative data were available. In addition the summer sampling program supplements the historical data by providing information not previously available on several parameters and reaches.

Results of the summer work indicate that water quality in several of the tributaries is significantly lower than in the Lower Fraser itself. Although this may present localised water quality problems, the impact of this quality difference on the Fraser River has not been assessed at this stage of the study.

The information obtained from the preliminary sampling program and historical review, which are presented in this report, have led to the development of a sampling program for the low flow period of 1973. This will provide additional information on seasonal quality variations which, together with the historical and summer 1972 data, can be used as a basis for formulating predictive capability for water quality in the Lower Fraser.

I. INTRODUCTION

This report covers work recently completed on a preliminary water quality survey of the Lower Fraser River system and is part of a wider study currently under way on water quality management in the Lower Fraser. During the initial planning stages of the water quality aspects of the Lower Fraser study, it became apparent that much of the existing data on levels of water quality in the Lower Fraser system were difficult to obtain. The importance of having these data for the purposes of the study, as well as the need to define general water quality characteristics as an aid in program planning, made it desirable to carry out a review of existing water quality studies and led to the formulation of a preliminary sampling program during the months of July and August, 1972.

The objectives of this survey were therefore as follows:

- to assemble, review and collate available data on existing water quality;

- to provide an overview of existing water quality in the Lower Fraser River and its tributaries; broad coverage within the study area, rather than intensive effort in specific locations, was selected as the basis for the sampling program;

- to obtain base line data which would aid in identifying the best direction for developing predictive capability for water quality in the Lower Fraser system.

II. DESCRIPTION OF THE FRASER RIVER

The Fraser River drainage basin, an area of 78,300 square miles, occupies most of the Interior Plateau of British Columbia situated between the Coast Mountains and the Rocky Mountains. The elevated nature of the Interior Plateau determines the principle feature of the basin's run-off, namely the spring floods derived from melting snows. Discharge measurement of the river at Hope shows a mean of 94,600 cubic feet per second (cfs) with extremes recorded as 536,000 cfs on May 31, 1948, and 12,000 cfs on January 8, 1916. (24).

At Hope the Fraser emerges from the Coast Mountains and flows through an alluvial valley and deltaic estuary to the Strait of Georgia. The flat gradient of the river in the Lower Fraser valley results in water levels and discharge rates being affected by tides as far up as Chilliwack some 60 miles from the river mouth. A map of the area of concern is at page 50.

The total drainage area of the Fraser River below Hope is 5970 square miles: half of this (3060 square miles) is contained in the Lillooet-Harrison tributary basin. Further significant proportions of the area are the alpine catchment basins of the Coquitlam River (80 square miles), Pitt River (450 square miles), Alouette River (80 square miles), Stave River (440 square miles), Chilliwack River (500 square miles), Wahleach Creek (50 square miles), and Silverhope Creek (120 square miles). These approximate tributary drainage areas total 1720 square miles. The remaining area (approximately 1200 square miles) is for the most part low lying, being drained by numerous small creeks and sloughs. (1).

It has become evident in discussions with project personnel and others concerned with the lower Fraser that there is confusion over the terminology used in describing the various stretches of the river. In an attempt to overcome this problem, the following delineates the nomenclature used throughout this report in discussing the lower Fraser River system.

The stretch of river from Hope to New Westminster has been called the Main Stem. At New Westminster, the Fraser branches into a major channel, (approximately 90% of the flow) herein called the Main Arm, entering the Strait of Georgia at Steveston, and a minor channel (approximately 10% of the flow) known as the North Arm, which enters the Strait at Point Grey. In the North Arm, bifurcation caused by Sea Island results in the Middle Arm, which enters the Strait over Sturgeon Banks. A number of small islands and training walls in the Main Arm near Ladner result in the formation of side channels, the major ones being Ladner Reach and Sea Reach which flow into Canoe Pass, the most southerly exit of Fraser River water.

It is recognized that certain reaches and channels of the river have local names. However, since some are in conflict and others are not commonly used, no reference to them has been made in this report.

III. HISTORICAL REVIEW OF WATER QUALITY STUDIES IN THE LOWER FRASER RIVER SYSTEM

Data Review

Prior to developing the preliminary summer sampling program, readily available reports and data on water quality in the Fraser system were assembled and reviewed. Between the time of the initial review and this writing, additional information on more recent water quality investigations has also been brought to the attention of the authors. The entire body of water quality studies is reviewed and summarized in this report as a basis for assessing water quality data obtained from the preliminary survey, as well as to provide base line data for program planning.

In 1967 a report entitled "Pollution and the Fraser - Report I" was prepared by C.A. Goldie for the Pollution Control Board of the Province (1). In addition to making an inventory of existing wastewater discharges under permit in the Lower Fraser Valley, reviewing hydrologic characteristics of the river system, and summarizing use requirements in the Lower Mainland, this report reviewed and summarized available information on the physical, chemical and bacteriological characteristics of waters in the Lower Fraser River system. Physical and chemical data reviewed were obtained largely from three reports (2) (3) (4) published in 1952, 1954 and 1955, and from unpublished data of the Provincial Health Branch (5) and the Greater Vancouver Sewerage and Drainage District (6). Bacteriological data reviewed included studies carried out from 1950-55 by B.C. Research (2) (4), from 1959-1965 by the Richmond and Vancouver units of the Provincial Health Branch (5), and from 1957-1966 by the Greater Vancouver Sewerage and Drainage District (6). In-stream results were compared with bacteriological quality at Vancouver beaches, Iona Beach and Sturgeon Bank waters.

The report concluded that the main stem of the Lower Fraser may be regarded "as a 'clean stream' in terms of BOD content," but that "rapid development of the Province could result in degradation of water quality so that planned preventative measures should be initiated .....". It was further concluded that existing bacteriological levels were undesirably high, with increasing trends in some areas, and that Upper Fraser watershed development, as well as Lower Mainland development, would likely alter water quality in the Lower Fraser River system. Recommendations for meeting or maintaining the existing water quality objectives were outlined.

Surveys of water quality and bottom-dwelling organisms in the Fraser and Thompson River systems were conducted by the International Pacific Salmon Fisheries Commission at several times during the 1963 to 1968 period (7). Water quality analyses included data on degradable and non-degradable organics, trace metals, organic pesticides and general physical and chemical parameters. No bacteriological data were obtained. The results obtained were discussed in terms of their seasonal variation and their significance to salmon migration. It was concluded that water quality in the Fraser varied seasonally, and that within the scope of the study existing water quality was, in general, satisfactory for fish migration. However, the limited scope of the study was recognized, as was the potential threat of pollutional hazards caused by continued development within the basin.

Unpublished data from the Fisheries Service, Department of the Environment (8) summarized the results of a dissolved oxygen and BOD monitoring program conducted over a three year period from 1969-71. This program included sampling sites in the Roberts Bank, Sturgeon Banks, Iona Beach, English Bay and False Creek areas, as well as in the North, Middle and Main Arms of the Lower Fraser. Samples were taken over a 3-4 month period during the summer-fall season. North Arm BOD values were in the range of <1 to 4 mg/l, with the majority toward the lower limit, while Main Arm data yielded negligible concentrations at all stations. DO levels in both reaches were generally high (> 90% saturation), although levels between 77 and 90% saturation were detected periodically at some stations in the North Arm. It was concluded that additional information was needed to assess adequately the potential influence of development on the oxygen balance in these reaches.

A recent report by B.C. Research (9) presented data from a comprehensive survey of water quality in the lower reaches below Port Mann Bridge during the months of September-October, 1971. Also included are data on sediment characteristics in these reaches. Survey procedures included profile sampling at selected stations over a tidal cycle, as well as grab sampling at over 30 stations within the study zone. The results of this program showed that, in general, dissolved oxygen levels were at or near saturation at all stations, although some low dissolved oxygen levels were obtained in bottom samples and isolated channels. No localized areas of elevated water temperature were reported. Data for North Arm stations generally indicated slightly lower quality in terms of free carbon dioxide, phenolic content and total organic carbon (TOC), while Main Arm stations were generally higher in oils and greases. The authors reported that biologically significant concentrations of copper, zinc, and lead were measured in some samples, although a large number of samples analyzed contained concentrations below those levels considered detrimental to fish life.

Nutrient loadings (phosphorus and nitrogen) were low, while levels of cyanide were undetectable at all stations. Iron, detergent and tannin/lignin levels showed some variation between samples, with no major trends evident. Organic content of sediments analyzed was between 0.5 and 1.0 per cent in the Main Arm stations, with values as high as 19.9 per cent in isolated side channels.

Recently, Rusch (10) developed a simulation model for predicting coliform levels in the Main Arm of the Fraser River between Port Mann and Garry Point. As a basis for comparing predicted and actual coliform levels, data was obtained from the Greater Vancouver Sewerage and Drainage District on coliform levels during the low flow winter months, at two depths (surface and 15 feet), and at several stations within the model boundaries. The 3-year (1968-1970) mean coliform levels were used for computational purposes. It is significant that coliform levels at the 15-foot depth were consistently lower than those at the surface, suggesting a high degree of vertical stratification in water quality during the low flow period.

Information on a number of water quality parameters is collected on a continuing basis by several governmental agencies. The Greater Vancouver Sewerage and Drainage District data on coliform, dissolved oxygen and temperature in the lower reaches for the 1968-1970 period (11) were reviewed, as were temperature data from the Water Survey of Canada (12) and data summaries from the National Water Quality Network (13). The National Water Quality Network includes data at Hope and Mission collected from 1960 to 1971 for a variety of quality parameters.

It is to be noted that a number of additional studies pertaining to various aspects of water quality in the Lower Fraser River system have been developed. Since these do not contain water quality data pertinent to the historical review they have not been referenced in the above discussion. They are listed in the Bibliography at the end of this report.

Discussion of Data Review

In an attempt to provide an overview of water quality in the Lower Fraser system based on available historical data, a summary tabulation was prepared showing the monthly concentration range reported for a number of water quality parameters within six reaches of the Lower Fraser River and the yearly range for several tributary sites. These data, along with descriptive information for the tabulation, are given in sections 1A - 1G of Table 1. Only data for studies conducted prior to 1972 have been included in Table 1.

Because of the diverse nature of the data sources and sampling dates represented in the monthly intervals of Table 1, and because of the diverse nature of analytical procedures used, no definite conclusions can be drawn regarding cause-effect relationships existing in the basin. The main purpose of the tabulation is to provide a convenient and rapid reference for the historical data, as well as to provide perspective from which program plans can be formulated.

The above notwithstanding, the following general observations regarding the historical data can be made (because of the scarcity of tributary data comments are restricted only to Lower Fraser waters):

(1) A seasonal temperature variation of the river is evident for all reaches tabulated, with monthly variations that are generally within 3 to 8°C.

(2) Dissolved oxygen levels in the Main Arm and the Main Stem of the Lower Fraser below Hope are consistently high. Although per cent saturation figures were not readily available in all circumstances, those values reported were all above 90%. Levels of 5-day Biochemical Oxygen Demand (BOD) are low, being generally ≤ 1 mg/l, although transient values of 2 to 3 mg/l have been reported.

(3) Reported levels of dissolved oxygen in the North Arm/Middle Arm reaches are slightly lower than for the Main Arm/Main Stem reaches. Although levels of $\geq$ 80% saturation appear to be representative, localized bottom concentrations below 80% saturation have been reported. Representative levels of BOD in the North and Middle Arms appear to be in the 2 to 4 mg/l range, again indicating slightly lower quality than in the Main Arm/Main Stem reaches.

(4) Total coliform levels vary widely in all reaches of the Lower Fraser. However, peak total coliform levels are consistently higher in the North and Middle Arms than in the Main Arm/Main Stem reaches. The lack of any historical data on fecal coliform levels or on other indicator organisms makes it impossible to judge the nature of the contributing sources; this difficulty is compounded by the general lack of coliform data at Hope and at other sites above Mission City.

(5) A seasonal variation in a number of quality parameters is evident in the data at upstream sites above the Pitt River confluence. Colour, turbidity, total solids, total volatile solids and suspended solids tend to be higher during the freshet period, presumably due to the natural scouring action of the high flows.

(6) Data on nutrient levels (nitrogen and phosphorus), trace organics (pesticides, PCB's,* tannin/lignin, phenols, TOC, detergents, oils and greases), trace metals (e.g., copper, mercury and lead), and toxic constituents such as cyanide are generally sparse in all reaches.

(7) The influence of tidal intrusion of salt water in the Main Arm and North Arm/Middle Arm reaches during the low flow period is evident in the conductance, chloride, sodium, potassium, calcium, magnesium and sulfate data. However, it was not possible to ascertain the influence of this intrusion on the other quality data for these reaches.

(8) The range of monthly flow variations at Hope for the period of record (1949-1971) represented by the tabulation is shown in Section 1F, as a basis for comparing future water quality data.

---

* PCB's = polychlorinated biphenyls.

TABLE 1: SUMMARY OF WATER QUALITY IN THE LOWER FRASER RIVER SYSTEM PRIOR TO 1972 (SECTIONS A-G)

Descriptive Information for Tables 1A-1G

Section 1A: Summary of Fraser River Water Quality prior to 1972 for stations within the North Arm and Middle Arm. Data from Reference Nos. 2, 4, 7, 8, 9, 11.
Length of Reach: 15 miles.

Section 1B: Summary of Fraser River Water Quality prior to 1972 for stations in Main Arm between Pattullo Bridge and Garry Point, including Canoe Pass and Sea Reach, but excluding data at Pattullo Bridge. Data from Reference Nos. 2, 7, 8, 9, 11.
Length of Reach: 15 miles.

Section 1C: Summary of Fraser River Water Quality prior to 1972 for stations in Main Stem between Pattullo Bridge and Pitt River (Douglas Island), including data at Pattullo Bridge. Data from Reference Nos. 2, 7, 8, 9, 11, 12, 13.
Length of Reach: 5 miles.

Section 1D: Summary of Fraser River Water Quality prior to 1972 for stations in Main Stem between Pitt River and Mission City, including data at Mission City Bridge. Data from Reference Nos. 2, 3, 7, 11, 12, 13.
Length of Reach: 24 miles.

Section 1E: Summary of Fraser River Water Quality prior to 1972 for stations in Main Stem between Mission City Bridge and Rosedale Bridge, including data at Rosedale Bridge. Data from Reference Nos. 3, 7, 12.
Length of Reach: 25 miles.

Section 1F: Summary of Fraser River Water Quality prior to 1972 at Hope. Data from Reference Nos. 2, 3, 7, 10, 12, 13.

Section 1G: Summary of Water Quality at Tributary Sites prior to 1972. Data from Reference Nos. 2, 3, 9.

TABLE 1: SUMMARY OF WATER QUALITY IN THE LOWER FRASER SYSTEM PRIOR TO 1972.

Section 1A: Fraser River Quality for North Arm / Middle Arm Reaches.

Quality Parameter \ Month	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
TEMP. (°C)	0.0-6.0	2.0-6.0	3.5-8.0	6.0-10.0	7.0-12.0	11.0-15.0	13.0-19.0	15.0-20.0	12.0-21.5	6.5-13.0	2.5-9.0	0.5-5.0
DO (mg/ℓ)	8.6-14.4	9.7-13.7	10.2-14.5	9.8-12.4	9.7-12.1	9.0-11.6	7.2-11.3	8.2-10.0	2.4-11.0	9.7-11.7	8.0-12.6	10.1-12.3
BOD (mg/ℓ)	2-3		<1-2	3-4	<4	<1-2	<1-3	<1-3	<1-4	1-3	2-4	2-3
COD (mg/ℓ)			6-9					3-7				
TOC (mg/ℓ)									1-16			
PHENOLS (μg/ℓ)									0.9-7.2			
OILS/GREASE (mg/ℓ)									0.5-3.0			
DETERGENTS (mg/ℓ)												
TAN/LIG (mg/ℓ)			0.30-0.45					0.15-0.35	0.3-6.9			
COLOUR UNITS												
P.B.I. (mg/ℓ)			N.D.-3.2					1.4-4.8				
TOT. COLIF./100mℓ	<30-150000	90-110000	<30-93000	<30-150000	<30-110000	40-150000	<30-230000	40-430000	40-230000	40-93000	40-230000	<30-93000
TURBIDITY UNITS								21-28	2-25			
TOT. SOLIDS (mg/ℓ)			96-23,143					77-117				
TOT. VOL. SOLIDS (mg/ℓ)			13-3,848					22-31				
SUSP. SOLIDS (mg/ℓ)			5-22					47-71	21-129			
DISS. SOLIDS (mg/ℓ)								70-286	46-3006		66-244	
CONDUCTANCE (μmho)	91-25280		109-27,800	116-379	93-99	77-92	79-86	92-404	64-3230		56-340	
KJELDAHL-N (mg/ℓ)									0.10-0.43			
NITRATE-N (mg/ℓ)			0.20-0.24	0.08-0.18		0.05-0.14		0.04-0.07	0.04-0.06		0.11-0.19	
NITRITE-N (mg/ℓ)	ND-0.01								0.003-0.004			
ORTHO-P (μg/ℓ)					3-30		5-10	<4	<4-40		<4	
TOTAL-P (μg/ℓ)									1-24			
ORGANOCHLORIDE (μg/ℓ)												
ORGANOPHOSPH. (μg/ℓ)												
TOTAL HARDNESS 1)			71-97					46-49	37-605			
TOT. ALKALINITY 1)	27-76		48-91	45-53	36-40	32-37	38	32-47	28-49		21-31	
pH	7.0-7.4		7.4-7.8	7.5-7.7	7.4-7.8	7.4-7.7	7.7-7.8	7.4-8.2	6.7-7.9		7.2-7.5	
FREE CO_2 (mg/ℓ)	1.2-12.5		4.6-4.9	3.5-4.9	2.2-5.0	2.4-6.8	2.5-3.5	2.0-4.4	0.7-9.6		3.4-6.8	
BICARB. (mg/ℓ)												
CARBONATE (mg/ℓ)												
Ca (mg/ℓ)	11.4-176		23.8-36.0	14.5-16.8	14.3-16.8	9.9-14.9	11.9-13.9	14.9-16.9	8.3-39.2		7.1-11.7	
Mg (mg/ℓ)	1.7-775		25.9-32.0	4.0-8.3	1.8-2.1	2.7-3.2	3.8	3.4-8.6	2.1-102.0		1.7-6.5	
Na (mg/ℓ)	2.2-4850		1.9-597	4.0-44	1.4-2.2	1.0-1.8	1.7-1.9	1.1-43.3	1.1-790		0.4-21.5	
K (mg/ℓ)	ND-206		11.1-21.7	1.2-2.0	0.9-1.6	0.5-1.4	1.2-1.9	1.4-3.8	0.6-125		0.5-4.8	
Cl (mg/ℓ)	2.4-9350		ND-11,600	1.2-81.1	<1.0-2.9	<1.0-1.6	≤1	1.0-80.0	1.0-1120			
F (mg/ℓ)											3.9-16.7	
I (mg/ℓ)												
SO_4 (mg/ℓ)	3.5-1135		38.3-42.6	23.6-44.0	2.3-9.4	5.3-10.4	3.6-4.6	5.5-18.7	7.8-45.0		0.1-69.1	
CN (mg/ℓ)												
Al (mg/ℓ)												
Cd (mg/ℓ)												
Cu (mg/ℓ)			ND					ND	0.002-0.052			
Hg (mg/ℓ)												
Fe (mg/ℓ)									0.45-0.85			
Pb (mg/ℓ)									0.001-0.034			
Mn (mg/ℓ)												
Ni (mg/ℓ)												
Ag (mg/ℓ)												
Zn (mg/ℓ)									0.0005-0.007			
As (mg/ℓ)												
SILICA (mg/ℓ) 2)			4.6	4.2-4.6		4.0-5.7		4.1-4.8	3.6-4.8			
FLOW (cfs)												

1) mg/ℓ as $CaCO_3$

2) mg/ℓ as SiO_2

ND = not detectable

Section 1 B: Fraser River Quality for Main Arm to Pattullo Bridge.

Quality Parameter \ Month	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
TEMP. (°C)	0.0-6.0	2.0-6.0	3.5-6.5	5.0-8.0	7.0-14.0	11.0-16.0	13.0-19.0	15.0-19.0	14.0-18.5	8.5-13.0	4.5	2.5-4.0
DO (mg/ℓ)	10.4-14.6	10.1-13.4	11.7-13.8	10.1-12.8	10.0-12.6	8.0-11.9	8.0-11.8	8.4-9.7	7.4-10.7	9.5-11.4	12.7	11.5-12.7
BOD (mg/ℓ)			≤ 1		< 4	< 4	< 4	≤ 1	< 4			
COD (mg/ℓ)			9-10					5-8				
TOC (mg/ℓ)									1.0-9.6	3-9		
PHENOLS (μg/ℓ)									1-4	0.9-3.6		
OILS/GREASE (mg/ℓ)									1.6-2.4	1.8-3.2		
DETERGENTS (mg/ℓ)												
TAN/LIG (mg/ℓ)			0.15-0.35					0.32-0.58	0.28-0.43	0.31-0.39		
COLOUR UNITS												
P.B.I. (mg/ℓ)			ND-4.4					1.2-3.0				
TOT. COLIF./100mℓ	<40-4300	<30-24000	40-24000	90-24000	70-9300	<30-21000	<30-15000	40-24000	70-24000	<30-43000	90-9300	<30-24000
TURBIDITY UNITS								21-28	6-23	2-12		
TOT. SOLIDS (mg/ℓ)			60-12,774					119-143				
TOT. VOL. SOLIDS (mg/ℓ)			9.0-2,061					21-32				
SUSP. SOLIDS (mg/ℓ)			3-122					59-60	8-58	11-39		
DISS. SOLIDS (mg/ℓ)								62-97	16-314	50-71		
CONDUCTANCE (μmho)	1280		101-19,250	188	102		88	95-1,037	96-330		72	
KJELDAHL-N (mg/ℓ)									0.04-0.24	0.02-0.53		
NITRATE-N (mg/ℓ)				0.1		0.05			0.03		0.11	
NITRITE-N (mg/ℓ)												
ORTHO-P (μg/ℓ)					26		5		<4		<4	
TOTAL-P (μg/ℓ)									3-25	<1-37		
ORGANOCHLORIDE (μg/ℓ)												
ORGANOPHOSPH. (μg/ℓ)												
TOTAL HARDNESS 1)			60-142					42-109	39-76	47-58		
TOT. ALKALINITY 1)	34		49-73	55	42	37	43	57-58	35-43	41-98	28	
pH	7.0		7.5-7.9	7.7	7.8	7.2	7.8	7.5-8.6	7.1-8.6	7.1-8.2	7.6	
FREE CO_2 (mg/ℓ)	7.2			3.3	3.1	4.1	2.8	1.0-3.7	0.2-3.1	0.4-6.7	3.4	
BICARB. (mg/ℓ)												
CARBONATE (mg/ℓ)												
Ca (mg/ℓ)	18.1			16.8	15.3	15.3	13.9	14.9	7.4-26.9	10.4-11.4	7.2	
Mg (mg/ℓ)	44			5.7	0.1	3.6	3.6	3.4	2.1-39.0	2.8-3.1	2.5	
Na (mg/ℓ)	222			18.3	1.8	2.0	3.5	1.8	0.4-38.4	1.7-2.5	0.6	
K (mg/ℓ)	8.9			1.4	1.0	1.4	1.7	1.4	1.6-3.0		0.7	
Cl (mg/ℓ)	373		ND-6,590	22.6	1.3	2.9	1.0	1-280	<1-65	1.5-3.0		
F (mg/ℓ)											5.6	
I (mg/ℓ)												
SO_4 (mg/ℓ)	26.3			48.9	2.4	3.8	4.5	6.8	16.1		1.8	
CN (mg/ℓ)												
Al (mg/ℓ)												
Cd (mg/ℓ)												
Cu (mg/ℓ)			ND-0.010					ND	0.002-0.033	0.002-0.003		
Hg (mg/ℓ)												
Fe (mg/ℓ)									0.5-0.85	0.2-0.4		
Pb (mg/ℓ)									<0.001-0.007	0.001-0.022		
Mn (mg/ℓ)												
Ni (mg/ℓ)												
Ag (mg/ℓ)												
Zn (mg/ℓ)									0.001-0.032	0.001-0.014		
As (mg/ℓ)												
SILICA (mg/ℓ) 2)				4.4		3.7		4.3-4.8	4.1-4.5			
FLOW (cfs)												

1) mg/ℓ as $CaCO_3$

2) mg/ℓ as SiO_2

ND = not detectable

TABLE 1 (cont'd)

Section 1C: Fraser River Quality for Main Stem between Pattullo Bridge and Pitt River.

Quality Parameter \ Month	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
TEMP. (°C)	0.5-5.5	0.5-5.0	3.5-5.5	4.0-9.0	5.5-12.0	10.5-16.0	13.5-20.0	15.0-20.5	12.0-19.5	9.0-14.5	4.5-9.0	0.5-6.0
DO (mg/ℓ)	11.4-15.0	11.8-13.8	12.2-14.0	11.2-12.6	10.4-11.9	9.4-11.7	8.2-10.3	8.2-9.8	9.2-10.1	10.5	11.5-12.4	12.3-12.4
BOD (mg/ℓ)			≤1	<.4	<4	<4	<4	<1	<4			
COD (mg/ℓ)			10-17					5-7				
TOC (mg/ℓ)									2-7			
PHENOLS (μg/ℓ)									0.4-3.2			
OILS/GREASE (mg/ℓ)									1.1-1.8			
DETERGENTS (mg/ℓ)												
TAN/LIG (mg/ℓ)			0.25-0.30					0.12-0.60	0.21-0.44			
COLOUR UNITS												
P.B.I. (mg/ℓ)			2.0-4.0					ND-2.2				
TOT. COLIF./100mℓ	230-24000	40-110000	140-24000	<30-9300	<30-2300	<30-24000	30-24000	<30-46000	<30-4300	230-23000	40-4300	90-12000
TURBIDITY UNITS								22-23	6-19			
TOT. SOLIDS (mg/ℓ)			74-101					103-114				
TOT. VOL. SOLIDS (mg/ℓ)			12-35					22-23				
SUSP. SOLIDS (mg/ℓ)			5-25					47-52	15-158			
DISS. SOLIDS (mg/ℓ)								66	24-96			
CONDUCTANCE (μmho)		101-110	107-118	111	95	84	60	91-97	78-87	78	59	
KJELDAHL-N (mg/ℓ)									0.04-0.42			
NITRATE-N (mg/ℓ)				0.09		0.1		0.05	0.2		0.13	
NITRITE-N (mg/ℓ)									0.006			
ORTHO-P (μg/ℓ)		<4			6		5		<4		<4	
TOTAL-P (μg/ℓ)									3-28			
ORGANOCHLORIDE (μg/ℓ)												
ORGANOPHOSPH. (μg/ℓ)												
TOTAL HARDNESS 1)			65-76					49	33-64			
TOT. ALKALINITY 1)		42	48-53	63	36	29	29	40-42	34-39		24	
pH		7.5	7.5-7.7	7.6	7.6	7.7	7.6	7.6-7.9	7.3-7.9	7.3	7.3	
FREE CO_2 (mg/ℓ)		5.4		3.8	2.5	2.2	7.7	1.9-3.0	0.7-6.5		4.9	
BICARB. (mg/ℓ)										33.5		
CARBONATE (mg/ℓ)												
Ca (mg/ℓ)		15.6		14.5	15.5	12.1	9.6	14.9	7.7-11.9	11.9	8.3	
Mg (mg/ℓ)		3.0		3.7	2.1	3.6	3.0	3.2	1.6-2.7	2.3	1.8	
Na (mg/ℓ)		2.6		4.1	1.7	3.6	1.7	1.4	1.1-3.4	1.6	0.4	
K (mg/ℓ)		0.1		1.4	1.3	1.9	1.1	1.4	1.0-1.4	1.4	4.8	
Cl (mg/ℓ)		1.6	ND-1.0	1.1	<1	1	<1	≤1	≤1-12.6	1.4		
F (mg/ℓ)											3.9	
I (mg/ℓ)												
SO_4 (mg/ℓ)		7.3		21.8	6.5	4.9	4.1	5.8	7.1	7.1	0.2	
CN (mg/ℓ)												
Al (mg/ℓ)												
Cd (mg/ℓ)												
Cu (mg/ℓ)			ND-0.006					ND	0.001-0.004			
Hg (mg/ℓ)												
Fe (mg/ℓ)									0.1-2.0			
Pb (mg/ℓ)									0.001-0.003			
Mn (mg/ℓ)												
Ni (mg/ℓ)												
Ag (mg/ℓ)												
Zn (mg/ℓ)									0.0005-0.0065			
As (mg/ℓ)												
SILICA (mg/ℓ) 2)				4.6		3.8		4.1-4.7	3.4-4.0			
FLOW (cfs)												

1) mg/ℓ as $CaCO_3$

2) mg/ℓ as SiO_2

ND = not detectable

Section 1D: Fraser River Quality for Main Stem between Pitt River and Mission City.

Quality Parameter \ Month	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
TEMP. (°C)	0.0-4.5	0.0-4.5	1.5-6.0	3.5-9.0	6.5-12.0	9.5-17.0	10.0-20.0	13.5-20.0	11.5-19.0	8.0-13.5	1.0-9.0	0.0-6.5
DO (mg/ℓ)	11.5-14.4	12.0-13.9	12.1-14.1	10.8-13.0	10.1-12.7	8.8-12.6	7.8-10.7	8.5-9.9	9.4-10.2	10.4-11.7	11.3-13.3	12.1-12.9
BOD (mg/ℓ)	1	<1-2		<1				1	≤1	<1	<1	
COD (mg/ℓ)	6-7	6-8		11-29				7	7-12		7	
TOC (mg/ℓ)									4-5			
PHENOLS (μg/ℓ)												
OILS/GREASE (mg/ℓ)												
DETERGENTS (mg/ℓ)				ND	ND							
TAN/LIG (mg/ℓ)	0.05-0.2	0.1-0.3		0.15-0.50				0.05	0.08-0.10	0.3	0.35	0.10
COLOUR UNITS	5-10	5-15	5-15	5-50	25-35	7-40	10-20	4-15	2-15	2-30	5-30	5-30
P.B.I. (mg/ℓ)	1	1						1.8	ND		1.4	
TOT. COLIF./100mℓ	30-2300	40-4300	<30-4300	23-7500	23-9300	<30-46000	<30-2300	<30-4300	<30-4300	<30-9300	<30-9300	<30-9300
TURBIDITY UNITS	3-9	1-15	3-15	9-110	35-210	27-200	13-85	3-40	7-76	2-35	7-50	6-25
TOT. SOLIDS (mg/ℓ)	83-86	97-133		74-876	292-439			153	89-164	90-102	79	
TOT. VOL. SOLIDS (mg/ℓ)	31-35	23		21-113				43	25-35	34-46	26	
SUSP. SOLIDS (mg/ℓ)	4-19	4-29	11-32	4-623	104-351	128-267	9-106	47-85	19-104	18-34	14-67	13-34
DISS. SOLIDS (mg/ℓ)	67-81	77-105	75-89	76-87	79-103	72-147	62-71	62-68	66-86	66-86	62-77	57-66
CONDUCTANCE (μmho)	68-129	96-151	102-137	124-133	96-120	63-104	62-98	93-105	83-132	85-130	93-120	82-126
KJELDAHL-N (mg/ℓ)												
NITRATE-N (mg/ℓ)	0.09-0.16	0.11-0.16	0.11	0.08-0.3	0.11-0.16	0.11-0.16	0.09-0.14	0.04-0.18	0.03-0.11	0.11	0.14-0.20	0.14-0.3
NITRITE-N (mg/ℓ)												
ORTHO-P (μg/ℓ)					3		12		<4	<4		
TOTAL-P (μg/ℓ)												
ORGANOCHLORIDE (μg/ℓ)				ND	ND							
ORGANOPHOSPH. (μg/ℓ)				ND	ND							
TOTAL HARDNESS 1)	49-63	45-72	51-63	54-82	43-77	38-55	32-47	39-50	39-64	47-62	44-57	38-96
TOT. ALKALINITY 1)	51-53	39-59	46-58	54-111	38-50	33-45	37-41	38-43	40-51	37-53	39-49	41-52
pH	7.3-7.9	7.4-7.9	7.7-8.0	7.3-8.0	7.3-7.7	7.5-8.0	7.5-8.0	7.4-7.9	7.2-8.0	7.4-8.1	7.4-7.9	7.3-7.9
FREE CO_2 (mg/ℓ)		7.1		1.9	4.7	2.4	3.9	1.0-2.4	1.3-1.8	3.5		
BICARB. (mg/ℓ)	51.5-60.0	49.1-78.3	56.6-68.3	61.0-111.0	37.7-66.9	35.7-57.8	40.5-53.7	40.8-53.7	42.6-59.0	45.1-57.3	51.6-58.8	43.7-55.6
CARBONATE (mg/ℓ)	0	0	0	0	0	0	0	0	0	0	0	0
Ca (mg/ℓ)	13.8-18.2	13.8-21.5	14.7-18.6	16.4-21.4	13.3-18.2	12.5-16.9	8.5-15.2	12.7-15.5	12.2-16.6	11.6-19.2	12.3-18.0	11.7-17.2
Mg (mg/ℓ)	2.5-3.3	2.4-4.5	3.2-4.3	1.7-5.0	1.5-3.3	2.1-3.8	2.1-4.2	2.1-3.3	2.2-3.2	2.7-3.6	2.6-3.5	2.3-3.7
Na (mg/ℓ)	1.5-2.6	1.7-3.4	1.9-3.0	0.9-4.0	1.4-2.4	1.0-2.2	1.1-2.1	1.1-6.4	1.3-1.8	1.2-2.2	1.3-2.5	1.7-3.3
K (mg/ℓ)	0.5-0.8	0.1-1.0	0.7-1.3	0.7-3.3	0.5-1.2	0.5-1.2	0.5-1.0	0.5-1.4	0.5-1.4	0.6-1.4	0.4-0.8	0.3-0.7
Cl (mg/ℓ)	0.5-1.3	ND-1.3	0.3-1.8	0.5-1.5	0.0-1.1	0.2-1.0	0.1-0.6	0.3-1.3	0.5-1.0	0.3-1.3	0.7-1.4	0.6-1.9
F (mg/ℓ)	0.05-0.1	0.05	0.05-0.15	0.05-0.15	0.05-0.10	0.02-0.17	0.05-0.1	0.04-0.1	<0.02-0.10	0.03-0.1	<0.05-0.06	0.03-0.1
I (mg/ℓ)				ND	ND							
SO_4 (mg/ℓ)	7.2-10.9	7.9-19.7	8.6-18.5	7.6-28.9	4.8-12.8	4.6-6.4	3.6-9.2	6.6-7.6	6.7-11.7	6.4-11.7	6.7-17.6	4.4-10.5
CN (mg/ℓ)				ND	ND							
Al (mg/ℓ)				0.40	0.26-0.64							
Cd (mg/ℓ)				ND	ND							
Cu (mg/ℓ)	ND-0.005	ND	0.009	ND-0.006	Tr.-0.065		<0.003-0.008	ND-0.007	0.01		0.002	0.002
Hg (mg/ℓ)				ND	ND							
Fe (mg/ℓ)	1.0-1.2	0.6	0.4-1.8	0.6-4.3	5.8-17.8	1.5-12.5	1.5-5.2	2.0-2.3	1.0-3.2	0.8-2.8	1.4-2.2	0.2-1.7
Pb (mg/ℓ)			<0.01	0.002	ND-0.040			<0.01				<0.01
Mn (mg/ℓ)			0.03					<0.01	0.02	0.1		
Ni (mg/ℓ)				0.02	0.007-0.02							
Ag (mg/ℓ)				Tr	Tr-0.006							
Zn (mg/ℓ)				ND	ND-0.01		<0.05	0.01				
As (mg/ℓ)				ND	ND							
SILICA (mg/ℓ) 2)	4.4-7.2	5.8-13.4	6.2-8.6	4.6-9.2	4.4-7.8	4.2-6.7	4.7-8.8	3.4-7.7	3.7-7.0	4.5-7.3	3.0-7.5	5.2-6.7
FLOW (cfs)												

1) mg/ℓ as $CaCO_3$

2) mg/ℓ as SiO_2

ND = not detectable

TABLE 1 (cont'd)

Section 1E : Fraser River Quality for Main Stem between Mission City and Rosedale Bridge.

Quality Parameter \ Month	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
TEMP. (°C)	0.5-3.0	1.0-4.0	1.0-4.0	4.0-4.5	9.0-10.5	12.5-14.0	15.5-17.5	14.5-18.5	14.0-15.0	7.0-8.0	0.5-2.5	1.5-5.0
DO (mg/ℓ)	14.0-14.7	13.3-14.1	13.6-14.1	13.1	11.7	10.9	9.4-10.4	9.3-9.9	10.5	12.2	13.5	14.1
BOD (mg/ℓ)	<1-3	<1	<1	<1	<1	1	1	1-2	<1		<1	<1
COD (mg/ℓ)	7-8	10-11	5-11	21		17	5	1-16	6	21	14	11
TOC (mg/ℓ)												
PHENOLS (μg/ℓ)												
OILS/GREASE (mg/ℓ)												
DETERGENTS (mg/ℓ)												
TAN/LIG (mg/ℓ)	0.1-0.4	0.1-0.5	0.2	0.6	0.5	0.7	0.4	0.4	0.1	0.2	0.2-0.3	0.5
COLOUR UNITS		5-10	10	7-20	10	40	5	10-15	5	5	15	15
P.B.I. (mg/ℓ)										3.6	1.6	
TOT. COLIF./100mℓ												
TURBIDITY UNITS	7	<1-9	5-560	9-200	70	150	105	40-50	16-25	20-250	6-15	4-15
TOT. SOLIDS (mg/ℓ)	91-115	102-122	101	445	208	314	147-233	158-284	120			100
TOT. VOL. SOLIDS (mg/ℓ)	31-52	35	32	59	47	35	20	19	34			28
SUSP. SOLIDS (mg/ℓ)	15-18	12-26	8-341	18-255	140	163-240	72-151	50-84	58	15-389	11-30	9
DISS. SOLIDS (mg/ℓ)			114	93-97		75	65	73-111	114	123	116	108
CONDUCTANCE (μmho)	128-136	122-156	128-180	133-153	109-116	97-99	99-103	83-111	114	120-123	116-128	108
KJELDAHL-N (mg/ℓ)												
NITRATE-N (mg/ℓ)			0.16	0.09-0.10		0.09	0.09			0.09		
NITRITE-N (mg/ℓ)												
ORTHO-P (μg/ℓ)												
TOTAL-P (μg/ℓ)												
ORGANOCHLORIDE (μg/ℓ)												
ORGANOPHOSPH. (μg/ℓ)												
TOTAL HARDNESS 1)	71	70-74	74-85	68-94	55-69	54-55	52-61	54-61	54-63	60-70	60-70	53-70
TOT. ALKALINITY 1)	56-65	60-61	63-65	64	52	46	47	46	50	50	57	60
pH	7.4-7.7	7.5-8.5	7.5-7.9	7.6-8.0	7.3-7.9	7.6-7.8	7.7-7.9	7.4-7.9	7.8-8.0	7.8-7.9	7.5	7.6-7.7
FREE CO_2 (mg/ℓ)												
BICARB. (mg/ℓ)		79-83	90	78-81	65	56	57	58-60	62	66	76	59
CARBONATE (mg/ℓ)		0	0	0	0	0	0	0	0	0	0	0
Ca (mg/ℓ)		20.5-22.0	23.6	20.3-20.5	15.8	15.5	16.9	15.9-19.6	16.3	17.9	17.5	15.8
Mg (mg/ℓ)		4.6	6.3	4.0-4.9	2.8	2.3	2.2	1.8-2.7	3.1	3.7	3.8	3.2
Na (mg/ℓ)		2.0-2.1	4.1	2.8-3.6	2.6	1.4	1.8	1.8-2.0	1.8	2.0	2.2	1.7
K (mg/ℓ)		0.7-0.8	1.3	1.0-1.2	1.0	0.7	0.7	0.6-0.9	0.6	0.8	0.9	0.4
Cl (mg/ℓ)	ND	<1	ND-<1	0	0	0	0	ND	0	0	0	0
F (mg/ℓ)				0.1		0.05			0.05			
I (mg/ℓ)												
SO_4 (mg/ℓ)		14.4	17.1	10.7-17.4	7.6	6.4	6.4	8.6-15.7	8.0	8.9	10.1	9.5
CN (mg/ℓ)												
Al (mg/ℓ)												
Cd (mg/ℓ)												
Cu (mg/ℓ)	0.006	ND-0.004	ND-0.001	0.004	0.002	0.010	0.016	0.018	ND	0.002	ND	0.008
Hg (mg/ℓ)												
Fe (mg/ℓ)			18.8	2.2-8.8		4.6	1.2	0.75				
Pb (mg/ℓ)												
Mn (mg/ℓ)												
Ni (mg/ℓ)												
Ag (mg/ℓ)												
Zn (mg/ℓ)												
As (mg/ℓ)												
SILICA (mg/ℓ) 2)		6.0-7.2	10.3	6.6-8.5	7.2	6.0	5.2	4.8-6.2	5.5	6.4	5.6	5.1
FLOW (cfs)												

Quality Parameter \ Month	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
TEMP. (°C)	0.5-2.0	1.0-3.5	0.5-5.5	0.5-9.5	4.5-14.5	9.0-14.0	11.0-18.5	12.5-21.0	11.5-19.5	6.0-14.5	2.0-7.0	0.0-6.5
DO (mg/ℓ)		14.4-14.7		14.0	12.2		11.1	9.4-10.9		11.1		
BOD (mg/ℓ)				< 4				1	< 1			
COD (mg/ℓ)								7				
TOC (mg/ℓ)												
PHENOLS (μg/ℓ)												
OILS/GREASE (mg/ℓ)												
DETERGENTS (mg/ℓ)												
TAN/LIG (mg/ℓ)								0.15	0.12			
COLOUR UNITS	3-15	1-15	3-40	10-35	6-55	5-20	0.15-10	5-10	5-30	5-20	5-30	5-20
P.B.I. (mg/ℓ)								4.8				
TOT. COLIF./100mℓ				33				49				
TURBIDITY UNITS	0.2-50.0	1.1-21.0	3-45	7.3-310	10-115	25-140	2.5-85	12-46	4-29	3.7-25	5.5-75	1.8-20
TOT. SOLIDS (mg/ℓ)								157	97			
TOT. VOL. SOLIDS (mg/ℓ)								41	32			
SUSP. SOLIDS (mg/ℓ)		3	32-91	196		144	97	84	34	24		
DISS. SOLIDS (mg/ℓ)		94	89-96	95		56	64	70		75		
CONDUCTANCE (μmho)	119-150	123-146	127-156	123-159	95-132	76-109	63-110	72-111	109-133	111-141	99-125	102-132
KJELDAHL-N (mg/ℓ)												
NITRATE-N (mg/ℓ)		0.13-0.16	0.09-0.3	0.09-0.12		0.09	0.09	0.05		0.03-0.09		
NITRITE-N (mg/ℓ)												
ORTHO-P (μg/ℓ)					26			8		15		
TOTAL-P (μg/ℓ)												
ORGANOCHLORIDE (μg/ℓ)												
ORGANOPHOSPH. (μg/ℓ)												
TOTAL HARDNESS 1)	34.8-69.8	53-66.5	62.3-74	64-74	48-70.2	36-50	35-55	38-56	48.4-64	53.3-62	45.9-60.6	50-64.9
TOT. ALKALINITY 1)	54-63	51-59	57-64	54-64	38-57	40-45	38-46	43-51	46-51	47-54	40-54	49-55
pH	7.2-8.1	7.1-8.1	7.8-8.2	7.2-8.0	7.3-7.8	7.5-7.9	7.4-8.0	7.5-8.0	7.1-8.0	7.4-8.0	7.5-8.0	7.5-8.1
FREE CO_2 (mg/ℓ)		5.3		2.2	3.4		5.8	1.9-3.9		2.8		
BICARB. (mg/ℓ)		70.8	73.7-75.2	74.9	56.6	41.5	53.7	51-53.7	61.0	48.9-61	63.4	53.7
CARBONATE (mg/ℓ)		0	0-2.9	0	0	0	0	0	0	0	0	0
Ca (mg/ℓ)	18-20.1	15.5-20.9	18.1-20.4	18.6-22.2	15-21	12.4-15.8	12.9-16.9	14.7-16.7	14.8-18.7	16.1-19.3	14.9-19.5	15.3-18
Mg (mg/ℓ)	3.8-4.8	3.1-4.1	3.7-5.1	2.8-5.5	2-5.4	1.2-2.6	2.3-3.9	2.3-4.3	2.8-3.3	2.8-3.6	2.1-3.1	2.9-4.8
Na (mg/ℓ)	1.9-2.9	2.3-9.2	2.0-4.0	2.0-4.4	1.5-2.6	0.8-1.4	1.1-1.8	1.0-1.7	1.4-2.0	1.2-3.0	1.4-2.3	1.7-3.2
K (mg/ℓ)	0.7-1.0	0.7-1.0	0.7-1.0	0.7-1.6	0.6-1.1	0.2-1.0	0.5-1.7	0.4-2.2	0.4-0.7	0.5-1.3	0.3-0.8	0.3-0.9
Cl (mg/ℓ)	≤1	<1-2	<1-2	<1-3	≤1	<1	<1	<1-2	≤1	≤1	≤1	<1-2
F (mg/ℓ)	0.05-0.09	0.06-0.09	0.11-0.14	<0.05-0.18	0.04-0.09	0.04-0.18	0.05	0.01	<0.05-0.07	<0.05-0.13	0.06-0.09	0.06-0.09
I (mg/ℓ)												
SO_4 (mg/ℓ)	8.5-11.7	8.9-28.2	6.2-18.9	6.5-32.2	4.7-8.1	5.4-6.6	5.4-8.0	5.5-8.8	7.0-10.5	6.6-13.1	6.7-9.1	7.7-15.0
CN (mg/ℓ)												
Al (mg/ℓ)												
Cd (mg/ℓ)												
Cu (mg/ℓ)							0.008	ND	0.001-0.008	0.002		
Hg (mg/ℓ)												
Fe (mg/ℓ)		0.6	1.5-2.4	11.1		7.4	1.9-3.0			1.3		
Pb (mg/ℓ)									< 0.01	<0.01		
Mn (mg/ℓ)									< 0.01			
Ni (mg/ℓ)												
Ag (mg/ℓ)												
Zn (mg/ℓ)												
As (mg/ℓ)												
SILICA (mg/ℓ) 2)	4.9-6.7	5.3-9.1	4.8-17.2	5.7-8.2	5.2-7.6	4.2-5.1	3.9-5.6	3.8-6.7	2.5-5.2	3.9-6.8	4.4-4.9	5.2-6.7
FLOW (cfs)	19,100-84,000	21,000-104,000	20,100-74,600	22,200-199,000	29,600-369,000	172,000-440,000	97,200-340,000	67,600-265,000	44,900-201,000	35,900-172,000	21,800-146,000	18,100-88,600

1) mg/ℓ as $CaCO_3$

2) mg/ℓ as SiO_2

ND = not detectable

TABLE 1 (cont'd)

Section 1G: Water Quality at Tributary Sites.

Quality Parameter \ Tributary	Pitt	Alouette	Stave	Chilliwack River	Sumas	Elk	Harrison					
TEMP. (°C)	2.0-19.0	18.5	16.5	0-16.5	21.0	11.0	2.5-17.5					
DO (mg/ℓ)	8.4-13.6						10.1-12.3					
BOD (mg/ℓ)							<4					
COD (mg/ℓ)	2-4											
TOC (mg/ℓ)												
PHENOLS (μg/ℓ)												
OILS/GREASE (mg/ℓ)												
DETERGENTS (mg/ℓ)												
TAN/LIG (mg/ℓ)												
COLOUR UNITS	10	0	7-15	0-15	20	3	0-10					
P.B.I. (mg/ℓ)												
TOT. COLIF./100mℓ	<30-300						2-4900					
TURBIDITY UNITS	2-8	<1	4-5	<1-105	12	<1	<1-9					
TOT. SOLIDS (mg/ℓ)												
TOT. VOL. SOLIDS (mg/ℓ)												
SUSP. SOLIDS (mg/ℓ)	6-25		2	13-141	23		4-5					
DISS. SOLIDS (mg/ℓ)	18-77	16.2	22.8	37-64	111	154	31-38					
CONDUCTANCE (μmho)	24	18	13-15	54-101	168	238	43-75					
KJELDAHL-N (mg/ℓ)												
NITRATE-N (mg/ℓ)	0.11	0	0.08	0.09-0.16	0.8	0.3	0-0.32					
NITRITE-N (mg/ℓ)												
ORTHO-P (μg/ℓ)							<4-7					
TOTAL-P (μg/ℓ)												
ORGANOCHLORIDE (μg/ℓ)												
ORGANOPHOSPH. (μg/ℓ)												
TOTAL HARDNESS 1)	7-36	8	6-12	24-47	65	115	18-23					
TOT. ALKALINITY 1)	6-8						15-18					
pH	6.3-7.4	7.0	6.8	7.2-7.9	7.4	8.1	7.0-7.9					
FREE CO_2 (mg/ℓ)	3.8-6.4						3.3-18.4					
BICARB. (mg/ℓ)	9.8	8.5	5.4-6.1	19.5-48.8	76	91	20-25					
CARBONATE (mg/ℓ)	0	0	0	0	0	2.4	0					
Ca (mg/ℓ)	1.9-10.8	3.2	2.2-4.8	7.5-15.0	16.0	41.3	6.2-10.5					
Mg (mg/ℓ)	0.1-2.0	0.1	0-0.1	0.6-2.4	6.2	3.0	0.3-2.4					
Na (mg/ℓ)	0.5-1.3	0.6	0.5-0.9	0.8-2.2	6.7	3.3	0.9-3.0					
K (mg/ℓ)	0.3	0.1	0.2	0.2-1.4	1.2	0.4	0.2-2.1					
Cl (mg/ℓ)	≤1	0	0	0	8.0	1.6	<1-5.3					
F (mg/ℓ)	0.05	0	0.1	0.05-0.1	0.1	0.05	0-0.1					
I (mg/ℓ)												
SO_4 (mg/ℓ)	3.6	3.1	0.5-10.0	3.1-13.8	7.6	39.5	3.8-28.4					
CN (mg/ℓ)												
Al (mg/ℓ)												
Cd (mg/ℓ)												
Cu (mg/ℓ)												
Hg (mg/ℓ)												
Fe (mg/ℓ)	0.68	0.1	0.11	0.58-5.0	2.3		0.06-0.4					
Pb (mg/ℓ)												
Mn (mg/ℓ)												
Ni (mg/ℓ)												
Ag (mg/ℓ)												
Zn (mg/ℓ)												
As (mg/ℓ)												
SILICA (mg/ℓ) 2)	3.0	3.4	2.7-4.6	4.0-7.3	21.0	10.9	4.5-6.4					
FLOW (cfs)												

1) mg/ℓ as $CaCO_3$

2) mg/ℓ as SiO_2

ND = not detectable

IV. DESCRIPTION OF THE SAMPLING PROGRAM

Sampling Network and Procedures

The study area for the preliminary sampling program included 24 tributary stations and 22 Fraser River sampling stations between Hope Bridge on the Main Stem and Garry Point on the Main Arm, Iona Island on the North Arm, Westham Island Bridge on Canoe Pass, and Dinsmore Bridge on the Middle Arm. Figure 1 shows the approximate location of both Fraser River and tributary stations used in the study program, along with a numerical designation to define location. A brief description of each station is given in Tables 2 and 3.

Because of the scope of the study area, encompassing an area approximately 100 river miles in length, it was necessary to divide sample collection into three logistic zones, each of which could be sampled within one 8 to 12 hour period: One zone encompassed the tributary stations (except T9, T12, and T17) and the Main Stem station at Hope, with samples being collected (via surface transportation) from bridge crossings. A 16½ foot research vessel was used to collect samples within two other logistic zones, consisting of all remaining stations above and below Port Mann Bridge, respectively.

Sampling frequency for water quality analyses varied from 1 to 5 times per station over the 2 month summer program. This variation in frequency was dictated in part by the high flow of the Fraser River during the early stages of the summer program, as well as by the results obtained in the early stages of the sampling program. Major stations were also sampled once for sediment characteristics. In all cases grab samples of water and sediment were taken.

Water Sampling Techniques

All water samples were taken at mid-stream and, with the exception of those for dissolved oxygen, were collected at the surface. Dissolved oxygen samples were collected either at a depth of 15 to 25 ft. below the surface or at mid-depth in the Fraser River, depending on channel characteristics, while all tributary samples were collected at mid-depth.

The depth sampling for dissolved oxygen was carried out using a 1-liter Nanson-type sampler. Surface samples were collected in a clean, plastic pail and portions were then distributed to clean sample jars for preservation and analysis. Bacteriological samples were collected in sterile sample jars.

Sediment Sampling Techniques

Bottom sediments were collected using a Dietz-Lafond heavy duty sampler having trip-operated jaws which collected sediment from the upper layers of the channel bottom. Teflon coated jaws reduced the possibility of sample contamination from the trace metal material used in the sampler construction.

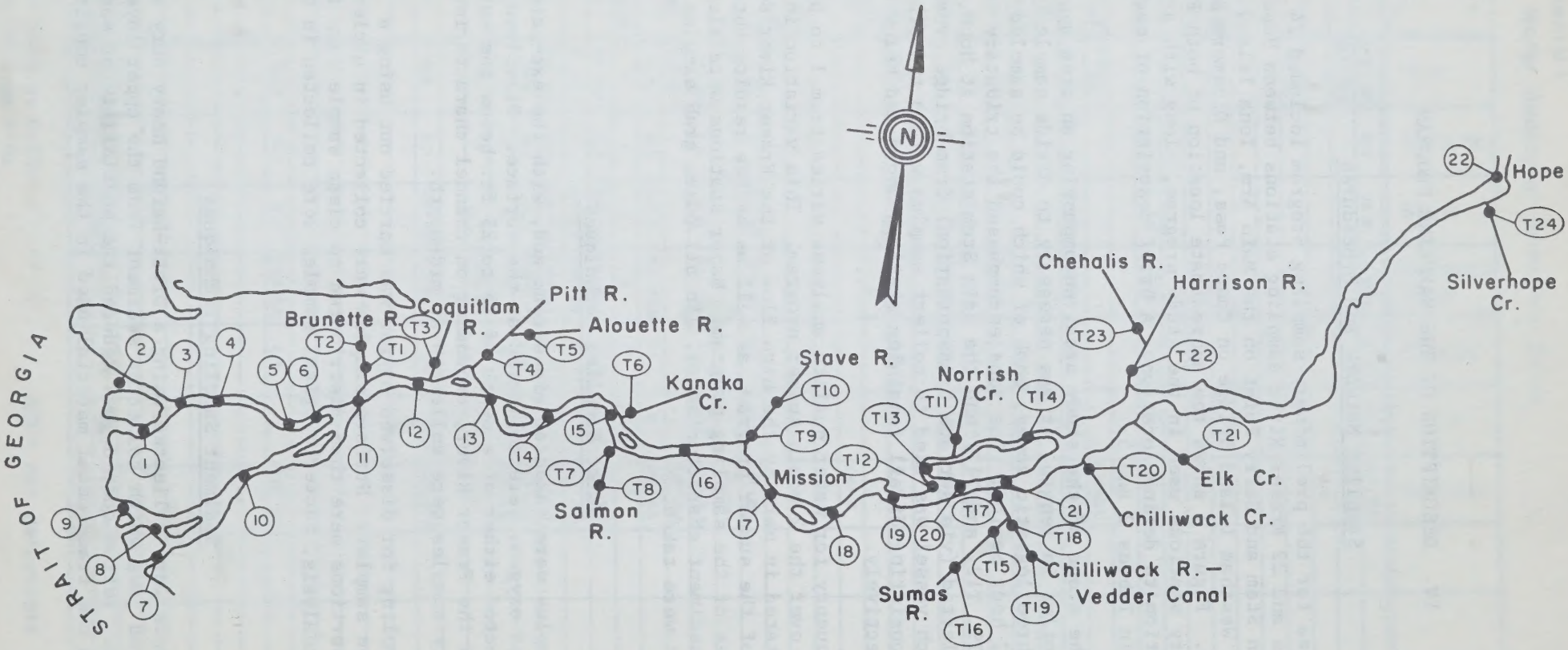


FIGURE 1: SCHEMATIC OF FRASER RIVER AND TRIBUTARY SAMPLING SITES.

Because of the small sample size collected by the sampler, it was often necessary to collect more than one sediment sample at each site. The several portions were combined and mixed prior to being stored in high wet-strength Kraft envelopes for shipment to the laboratories.

Quality Parameters Investigated

Water samples collected during the summer program were analyzed for the 29 quality parameters outlined in Table 4. These parameters were selected in order to define quality levels in the following 5 broad categories: degradable and non-degradable organics, bacteriological characteristics, nutrient materials, trace metals and general chemical parameters. Although initial plans called for analyses of both sediment and water to recover residual chlorinated hydrocarbons, laboratory restrictions made this impossible.

Sediment samples collected were analyzed for the 12 parameters outlined in Table 4. These parameters were selected in order to define nutrient content, organic content and trace metal concentrations in the bottom sediments at the time of sampling. Sampling also afforded an opportunity to evaluate grain size and physical characteristics visually.

Analytical Procedures

Unless otherwise noted in the procedures, all water quality analyses were conducted on unfiltered water samples, thus incorporating quality characteristics of both the dissolved and suspended load. Analyses for pH and surface temperature were carried out directly in the field, while all other analyses were carried out in the laboratory on field-preserved samples. Specialized techniques were used to avoid contamination of samples for trace metal analyses. Details of preservation techniques and analytical procedures used for the water quality analyses are given in the Appendix.

Sediment analyses were conducted on gross samples collected from the surface of the river bed; no attempt was made to define quality variations with sediment particle-size or with sediment depth, although screening was used to eliminate large particles in several cases. Where necessary, field preservation and anti-contamination procedures similar to those required for the water samples were used at the time of collection. Details of these procedures and of the analytical techniques used for the sediment analyses are also given in the Appendix.

TABLE 2: IDENTIFICATION OF FRASER RIVER SAMPLING STATIONS

Sta. No.	Reach	Title/Description
1	Middle Arm	Fraser R. at Dinsmore Bridge
2	North Arm	Fraser R. at Iona Island
3	North Arm	Fraser R. at Oak St. Bridge
4	North Arm	Fraser R. at Fraser St. Bridge: North Channel
5	North Arm	Fraser R. at CNR Bridge
6	North Arm	Fraser R. at Queensboro Bridge
7	Canoe Pass	Fraser R. at Canoe Pass: Westham Island Bridge
8	Sea Reach	Fraser R. at Westham Island
9	Main Arm	Fraser R. at Garry Point
10	Main Arm	Fraser R. at Tilbury Island
11	Main Stem	Fraser R. at Pattullo Bridge
12	Main Stem	Fraser R. at Port Mann Bridge
13	Main Stem	Fraser R. at Barnston Island West
14	Main Stem	Fraser R. at Barnston Island East
15	Main Stem	Fraser R. at Kanaka: Below confluence of Kanaka Cr.
16	Main Stem	Fraser R. at Whonnock Narrows
17	Main Stem	Fraser R. at Silverdale Narrows
18	Main Stem	Fraser R. at Mission City Bridge
19	Main Stem	Fraser R. at Hatzic: Below confluence of Hatzic Lake Outlet
20	Main Stem	Fraser R. below Vedder Canal
21	Main Stem	Fraser R. above Vedder Canal
22	Main Stem	Fraser R. at Hope Bridge

TABLE 3: IDENTIFICATION OF TRIBUTARY SAMPLING STATIONS

Sta. No.	Title/Description
T 1	Brunette R. at Braid Street
T 2	Brunette R. at Cariboo Road
T 3	Coquitlam R. at Kingsway Street Bridge
T 4	Pitt R. at Route 7 Bridge
T 5	Alouette R. at Harris Road Bridge
T 6	Kanaka Cr. at Route 7 Bridge
T 7	Salmon R. at Mackinnon Rd.
T 8	Salmon R. at Springbrooke Rd. (72nd Ave.)
T 9	Stave R. at Mouth: At Route 7 Bridge
T10	Stave R. at Stave Falls: Upstream side of dam
T11	Norrish Creek at Hawkins Pickle Road
T12*	Nicomen Slough at Mouth: Upstream of Fraser confluence
T13*	Nicomen Slough at Dewdney: At Route 7 Bridge
T14*	Nicomen Slough at Deroche: At Route 7 Bridge
T15	Sumas R. at No. 1 Road: Downstream of control structure
T16	Sumas R. at Boundary Road: At U.S. Border
T17	Vedder Canal at Mouth: At confluence with Fraser R.
T18	Vedder Canal at Highway 401 Bridge
T19	Chilliwack R. at Vedder Crossing
T20	Chilliwack Cr. at Wolfe Road
T21	Elk Creek at Prairie Central Road
T22	Harrison R. at Route 7 Bridge
T23	Chehalis R. at Morris Valley Road
T24	Silverhope Cr. at Route 1 Bridge

* For purposes of identification, Nicomen Slough is classified as a tributary.

TABLE 4: QUALITY PARAMETERS INVESTIGATED DURING THE PRELIMINARY SAMPLING PROGRAM

Parameter	Analysis[1] Water	Analysis[1] Sediment
Temperature	✓	
Dissolved Oxygen (DO)	✓	
Biochemical Oxygen Demand (BOD)	✓	
Total Organic Carbon (TOC)	✓	
Total Coliform	✓	
Fecal Coliform	✓	
Kjeldahl Nitrogen	✓	✓
Nitrate Nitrogen	✓	
Total Phosphorus	✓	✓
Trace Metals[2]	✓	✓
Colour	✓	
Turbidity	✓	
Total Suspended Solids	✓	
Volatile Suspended Solids	✓	
Total Dissolved Solids	✓	
Conductance	✓	
Chloride	✓	
pH	✓	
Total Hardness	✓	
Total Alkalinity	✓	
Volatile Dry Weight[3]	✓	✓

[1] Samples analyzed for parameters checked (✓)

[2] Water samples analyzed for Cd, Co, Cu, Fe, Pb, Mn, Mo, Ni, Ag and Zn. Sediment samples analyzed for Co, Cr, Cu, Fe, Pb, Mn, Mo, Ni and Ag.

[3] Volatile dry weight assumed equivalent to organic content of sediments.

V. RESULTS OF SAMPLING PROGRAM

Fraser River Water Quality

The results of the water quality analyses for the 22 Fraser River stations are summarized in Table 5. Where stations were sampled more than once, and mean values are considered representative of the data range, only the mean is reported. In other cases the range of data has been tabulated.

The data show that water temperature varied from a low of 13.5°C at Hope (sampled July 10, 1972) to a high of 19.5°C in the Main Stem above Vedder Canal (sampled August 7, 1972). Values for 5-day BOD were generally <1 mg/l, while dissolved oxygen values ranged from 9.0 to 11.2 mg/l (95 to 107% saturation). Total organic carbon levels varied from 1.5 to 3.7 mg/l.

Results of the bacteriological analyses yielded total coliform levels of <100/100 ml to 9300/100 ml and fecal coliform levels of <20/100 ml to 790/100 ml. Fecal coliform/total coliform ratios varied from 0.05 to 0.35.

Nutrient determinations indicated Kjeldahl-nitrogen levels generally of 0.1 mg-N/l, with slightly higher levels (0.2 mg-N/l) at three upstream stations in the vicinity of Vedder Canal (Stations 19, 20 and 21). Nitrate concentrations ranged from 0.02 to 0.06 mg-N/l. Total phosphorus levels varied from <20 to 90 μg-P/l.

Concentrations of cadmium, cobalt, lead, molybdenum, nickel and silver were below the detectable levels of the analytical procedures used. Concentrations of copper were between 0.005 and 0.01 mg/l at all sites except the Middle Arm station (No. 1) which was 0.020 mg/l. Iron levels varied between 0.56 and 2.3 mg/l, while manganese was in the 0.03 to 0.08 mg/l range. Zinc concentrations were between 0.005 and 0.015 mg/l, with the exception of the Middle Arm station (No. 1) and the Iona Island station (No. 2), which were 0.22 and 0.020 mg/l, respectively.

Suspended residue varied between 19 and 71 mg/l, with a volatile content of <6 to 77%. The ranges of turbidity, apparent colour and true colour levels observed were 42 to 80, 10 to 30, and 5 to 10 units, respectively.

Levels of pH varied between 7.5 and 8.0. Alkalinity and hardness concentrations were relatively consistent, with ranges of 30 to 44 and 35 to 49 mg/l, as $CaCO_3$, respectively.

Total dissolved residue varied between 46 and 110 mg/l, and conductance ranged between 78 and 133 μmho, with no consistent relationship between the two parameters. Chloride levels were consistently below 10 mg/l at all stations.

Tributary Water Quality

The results of the tributary water quality analyses are summarized in Table 6. Mean values for replicate samplings are recorded where they can be considered representative of the range observed; in other cases the range is tabulated.

As expected, tributary quality varied widely. Water temperatures observed ranged from a low of 8.0°C in Norrish Creek (sampled on July 10, 1972) to a high of 27.0°C in the Salmon River (sampled on July 17, 1972). Concentrations of 5-day BOD varied from <1 mg/l at twelve tributary sites to >22 mg/l at the downstream station on the Salmon River (T7). Dissolved oxygen variations ranged from above 95% saturation at 14 tributary stations to a low of zero percent saturation in Chilliwack Creek (sampled on August 21, 1972). Total organic carbon levels ranged from 0.5 at the Chilliwack River station (T19) to 5.4 mg/l at both the downstream Sumas River station (T15) and the Chilliwack Creek station (T20).

Bacteriological content, measured as total and fecal coliform, varied from ≤20/100 ml for both parameters at several sites to a peak total coliform level of 160,000/100 ml in Chilliwack Creek (T20) on August 21, 1972, and a peak fecal coliform level of 5400/100 ml at the upstream Sumas River station (T16) on July 10, 1972. Fecal coliform/total coliform ratios varied from <0.001 to 1.0.

Nutrient determinations indicated Kjeldahl and nitrate-nitrogen levels of ≤0.1 to 1.7 and 0.01 to 2.9 mg/l as nitrogen, respectively. Total phosphorus varied from <20 to 260 μg/l as phosphorus.

Cadmium, cobalt, lead, molybdenum, nickel and silver were all below the detectable levels of the analytical procedures used. However, detectable concentrations of copper, iron, manganese and zinc were found. Copper levels varied from <0.005 to 0.015 mg/l, while zinc levels ranged from <0.005 to 0.02 mg/l. Iron and manganese concentration ranges were from <0.1 to 2.73 mg/l and <0.01 to 0.45 mg/l, respectively.

Water samples from a number of stations yielded total and volatile suspended residue levels <1 mg/l. Peak levels of total and volatile suspended residue were 43 and 29 mg/l, respectively, with volatile content varying from 10 to 94 percent. Turbidities varied between 1 and 52 units, while ranges of apparent and true colour were <5 to 120 and <5 to 100 units, respectively.

Levels of pH varied between 6.4 and 8.0. Alkalinity and hardness concentrations were quite varied, with ranges of 2 to 89 and <1 to 111 mg/l, as $CaCO_3$, respectively.

Total dissolved residue ranged from <1 to 224 mg/l, while conductance levels observed varied between 9 and 243 μmho. No consistent relationship was observed between total dissolved solids and conductance measurements. Chloride levels were generally <10 mg/l; however, concentrations up to 23 mg/l were observed at several sites.

Sediment Characteristics

The results of the sediment analyses for samples collected from the Fraser River and from the tributaries are shown in Tables 7 and 8, respectively.

Fraser River sediments varied from 0.16 to 0.60 per cent volatile content, with the majority of samples being between 0.20 and 0.40 per cent. Kjeldahl nitrogen and total phosphorus levels in the Fraser sediments varied from 120 to 730 mg-N/Kg and 800 to 3150 mg-P/Kg. All but one sample (Station 17) were below 230 mg-N/Kg and 1700 mg-P/Kg.

Copper and cobalt concentrations were generally in the 20 to 30 mg/Kg range, although several sites had levels outside this range. Lead content varied between 4 and 12 mg/Kg.

Concentrations of chromium found in the Fraser River sediments were between 80 and 2000 mg/Kg although most samples were in the 125 to 800 mg/Kg range. Iron and manganese variations were 49 to >140 gm/Kg and 200 to 1000 mg/Kg, respectively. Nickel levels varied between 30 and 200 mg/Kg while molybdenum and silver concentrations were all <2 mg/Kg and <1 mg/Kg, respectively.

Tributary sediments had widely ranging volatile contents, ranging between 0.36 and 3.48 per cent. Similarly, Kjeldahl nitrogen content varied between 120 and 5800 mg-N/Kg, while total phosphorus levels were between 700 and 2500 mg-P/Kg.

The variation in sediment copper levels found at tributary sites was 10 to 50 mg/Kg, although all but two sites were between 40 and 50 mg/Kg. Cobalt varied between 10 and 30 mg/Kg. Chromium, nickel and lead ranges were 60 to 200, 20 to 125, and 7 to 70 mg/Kg, respectively.

Variations in iron and manganese content of sediments from the tributary sites were 49 to >140 gm/Kg and 300 to 800 mg/Kg, respectively. Molybdenum and silver levels were all <2 mg/Kg and <1 mg/Kg, respectively.

TABLE 5 : FRASER RIVER WATER QUALITY.

WATER QUALITY PARAMETER		STATION NUMBER AND LOCATION							
		Middle Arm	North Arm					Canoe Pass	Sea Reach
		1	2	3	4	5	6	7	8
TEMPERATURE (°C)		17.0	17.0	17.0	17.0	17.0	17.0	16.5	16.0
DISS. OXYGEN (mg/ℓ)		9.5	9.5	9.2	9.5	9.6	9.6	9.6	9.6
5-DAY BOD (mg/ℓ)		< 1	< 1	< 1	< 1	< 1	< 1	< 1	1
TOT. ORG. CARBON (mg/ℓ)		1.5	2.3	1.8	–	–	1.6	2.1	–
COLIFORM (MPN/100mℓ)	Total [1]	9 300	–	700	1100	< 100	2000	600	800
	Fecal [1]	–	–	–	–	–	–	–	–
NITROGEN (mg/ℓ – N)	Kjeldahl	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1
	Nitrate	0.05	0.05	0.03	0.04	0.05	0.04	0.05	0.04
TOT. PHOSPHORUS (μg/ℓ-P)		80	< 20	30	90	50	60	30	50
TRACE METALS (mg/ℓ) [2]	Copper	0.020	0.010	0.005	0.010	0.005	0.005	0.005	0.005
	Iron	0.65	0.67	0.90	0.92	0.69	0.68	0.73	0.56
	Manganese	0.03	0.04	0.05	0.05	0.04	0.04	0.05	0.03
	Zinc	0.220	0.020	0.015	0.010	0.010	0.010	0.010	0.010
SUSPENDED SOLIDS (mg/ℓ)	Total	57	26	48	59	47	54	51	35
	Volatile	29	20	19	17	22	12	21	13
TURBIDITY (APHA Units)		50	53	50	57	53	55	64	57
COLOUR (Pt-Co Units)	Apparent	20	20	20	10	20	20	20	20
	True	10	10	5	10	10	10	10	10
pH		7.9	7.8	7.8	7.7	7.7	8.0	7.5	7.5
TOTAL ALKALINITY (mg/ℓ as $CaCO_3$)		35	35	35	35	33	33	38	36
TOTAL HARDNESS (mg/ℓ as $CaCO_3$)		39	44	39	39	37	37	42	39
DISS. SOLIDS (mg/ℓ)		87	89	97	66	75	58	70	65
CONDUCTANCE (μmho)		81	133	82	83	78	79	88	96
CHLORIDE (mg/ℓ)		< 10	10	< 10	< 10	< 10	< 10	< 10	< 10

[1] Where range is recorded, parenthesis ( ) indicate corresponding total and fecal coliform readings.

[2] Concentrations found were below the detectable level in mg/ℓ, for the following trace metals : Cd (0.003), Co (0.020), Pb (0.060), Mo (0.030), Ni (0.020), Ag (0.002).

TABLE 5 : (cont'd) :

WATER QUALITY PARAMETER		STATION NUMBER AND LOCATION							
		Main Arm		Main Stem					
		9	10	11	12	13	14	15	16
TEMPERATURE (°C)		17.0	16.5	16.0	17.5	17.5	18.0	18.0	18.0
DISS. OXYGEN (mg/ℓ)		9.6	—	9.6	9.5	9.4	9.3	9.5	9.4
5-DAY BOD (mg/ℓ)		< 1	< 1	2	< 1	< 1	1	< 1	< 1
TOT. ORG. CARBON (mg/ℓ)		1.7	3.7	3.2	1.9	—	—	1.5	—
COLIFORM (MPN/100mℓ)	Total [1]	300	< 100	600	< 100 – (790)	(790) – 4900	230	230	330
	Fecal [1]	—	—	—	(170)	(40)	80	50	50
NITROGEN (mg/ℓ – N)	Kjeldahl	0.1	0.1	0.1	0.1	0.1	< 0.1	0.1	0.1
	Nitrate	0.06	0.06	0.02	0.04	0.05	0.05	0.06	0.04
TOT. PHOSPHORUS (μg/ℓ – P)		50	50	70	20 – 60	<20 – 40	20	40	50
TRACE METALS (mg/ℓ) [2]	Copper	0.005	0.010	0.005	0.005	0.01	0.005	0.010	0.005
	Iron	0.78	0.61	0.82	0.66	0.69	2.3	0.89	0.81
	Manganese	0.03	0.04	0.04	0.03	0.04	0.06	0.04	0.04
	Zinc	0.005	0.015	0.010	0.010	0.010	—	—	—
SUSPENDED SOLIDS (mg/ℓ)	Total	—	46	46	35	52	32	19	56
	Volatile	16	13	17	16	19	—	< 1	5
TURBIDITY (APHA Units)		57	65	65	48	66	50	43	65
COLOUR (Pt-Co Units)	Apparent	20	20	20	30	20	20	10	20
	True	10	10	10	10	10	5	10	10
pH		7.5	7.5	7.5	7.8	7.9	7.8	7.7	7.8
TOTAL ALKALINITY (mg/ℓ as $CaCO_3$)		36	37	35	31	38	36	36	38
TOTAL HARDNESS (mg/ℓ as $CaCO_3$)		39	41	38	35	47	39	40	41
DISS. SOLIDS (mg/ℓ)		46	76	110	67	70	88	82	76
CONDUCTANCE (μmho)		96	87	82	78	87	84	84	87
CHLORIDE (mg/ℓ)		< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

[1] Where range is recorded, parenthesis ( ) indicate corresponding total and fecal coliform readings.

[2] Concentrations found were below the detectable level in mg/ℓ, for the following trace metals : Cd (0.003), Co (0.020), Pb (0.060), Mo (0.030), Ni (0.020), Ag (0.002).

TABLE 5 (cont'd):

WATER QUALITY PARAMETER		STATION NUMBER AND LOCATION							
		Main Stem							
		17	18	19	20	21	22		
TEMPERATURE (°C)		18.0	18.0	18.0	18.0	19.5	13.5		
DISS. OXYGEN (mg/ℓ)		9.3	9.5	9.4	9.3	9.0	11.2		
5-DAY BOD (mg/ℓ)		< 1	< 1	< 1	< 1	< 1	1		
TOT. ORG. CARBON (mg/ℓ)		–	–	–	3.2	–	–		
COLIFORM (MPN/100mℓ)	Total [1]	330	(130) – 490	–	800	2400	790		
	Fecal [1]	20	(< 20) – 60	–	200	790	60		
NITROGEN (mg/ℓ – N)	Kjeldahl	0.1	0.1	0.2	0.2	0.2	0.1		
	Nitrate	0.05	0.04	0.04	0.04	0.05	0.06		
TOT. PHOSPHORUS (μg/ℓ-P)		30	20 – 40	≤ 20	20 – 50	40	20 – 40		
TRACE METALS (mg/ℓ) [2]	Copper	0.005	0.005	0.005	0.005	0.005	0.005		
	Iron	0.82	0.69	0.58	0.75	0.89	0.71		
	Manganese	0.05	0.04	0.04	0.05	0.05	0.08		
	Zinc	–	–	–	–	–	0.010		
SUSPENDED SOLIDS (mg/ℓ)	Total	30	40	37	49	57	71		
	Volatile	< 1	< 1	3	7	3	6		
TURBIDITY (APHA Units)		42	51	48	60	73	80		
COLOUR (Pt-Co Units)	Apparent	20	20	30	20	30	20		
	True	10	10	10	10	10	10		
pH		7.8	7.8	7.7	7.7	7.5	8.0		
TOTAL ALKALINITY (mg/ℓ as $CaCO_3$)		37	30	35	44	42	37		
TOTAL HARDNESS (mg/ℓ as $CaCO_3$)		41	42	46	49	47	43		
DISS. SOLIDS (mg/ℓ)		73	84	60	77	74	83		
CONDUCTANCE (μmho)		83	88	92	96	99	90		
CHLORIDE (mg/ℓ)		< 10	< 10	< 10	< 10	< 10	< 10		

[1] Where range is recorded, parenthesis ( ) indicate corresponding total and fecal coliform readings.

[2] Concentrations found were below the detectable level in mg/ℓ, for the following trace metals: Cd (0.003), Co (0.020), Pb (0.060), Mo (0.030), Ni (0.020), Ag (0.002).

TABLE 6 : WATER QUALITY AT TRIBUTARY SITES.

WATER QUALITY PARAMETER		STATION NUMBER AND LOCATION							
		Brunette River		Coquitlam River	Pitt River	Alouette River	Kanaka Creek	Salmon River	
		T1	T2	T3	T4	T5	T6	T7	T8
TEMPERATURE (°C)		23.5	22.5	8.5-12.5	15	15.5-20.5	–	9.0-27.0	12.5-18.5
DISS. OXYGEN (mg/ℓ)		7.6	7.5	9.4-11.5	9.9	7.1-8.2	9.4	0.4-6.9	8.4-9.6
5-DAY BOD (mg/ℓ)		>7	3	<1-2	<1	1-4	2	3->22	≤1
TOT. ORG. CARBON (mg/ℓ)		5.0	–	2.9	1.1	–	–	3.1	–
COLIFORM (MPN/100mℓ)	Total [1]	24000	300	170-790	–	70-2400	270	200-2200	230-3500
	Fecal [1]	<200 800	–	50-490	–	20-<200	170	<200-1300	130-3500
NITROGEN (mg/ℓ-N)	Kjeldahl	0.5	0.6	0.1-0.2	0.1	0.2-0.4	0.4	0.45-1.7	0.2-0.9
	Nitrate	0.20	0.53	0.12-0.15	0.05	0.02-0.19	0.01	0.01-2.0	2.0-2.9
TOT. PHOSPHORUS (μg/ℓ-P)		60	60	<20-40	20	<20-60	–	140-260	30-50
TRACE METALS (mg/ℓ) [2]	Copper	0.01	0.01	0.005	0.005	0.005	0.005	0.005	0.005
	Iron	0.70	0.66	0.11-0.24	0.24	0.60-0.72	0.95	0.42-2.73	0.14-0.57
	Manganese	0.29	0.11	0.01-0.02	0.01	0.02-0.03	0.14	0.03-0.45	0.02-0.04
	Zinc	–	0.02	0.005	0.005	0.005	–	0.005	0.005
SUSPENDED SOLIDS (mg/ℓ)	Total	4	30	5-30	7	10-17	22	3-43	<1-34
	Volatile	3	21	3-24	–	5-17	15	1-24	<1-29
TURBIDITY (APHA Units)		20	6	4-8	17	4-10	28	11-49	5-10
COLOUR (Pt-Co Units)	Apparent	60	100	10-30	5	30-60	40	30-120	20-40
	True	40	70	5-20	<5	10-50	20	10-100	20-30
pH		7.2	6.9	6.7-7.0	7.2	6.4-6.7	7.2	6.5-7.1	7.4-7.6
TOTAL ALKALINITY (mg/ℓ as $CaCO_3$)		41-56	26	4-15	9	8-10	15	25-48	22-32
TOTAL HARDNESS (mg/ℓ as $CaCO_3$)		50-54	39	7-16	6	9-16	14	24-47	34-44
DISS. SOLIDS (mg/ℓ)		222	8	2-120	22	10-100	15	19-224	35-192
CONDUCTANCE (μmho)		150	132	20-44	27	30-46	49	77-149	99-108
CHLORIDE (mg/ℓ)		–	23	<10	<10	<10	–	<10-22	<10

[1] Where range is recorded, parenthesis ( ) indicate corresponding total and fecal coliform readings.

[2] Concentrations found were below the detectable level in mg/ℓ, for the following trace metals : Cd (0.003), Co (0.020), Pb (0.060), Mo (0.030), Ni (0.020), Ag (0.002).

TABLE 6 (cont'd):

WATER QUALITY PARAMETER		STATION NUMBER AND LOCATION							
		Stave River		Norrish Creek	Nicomen Slough			Sumas River	
		T9	T10	T11	T12	T13	T14	T15	T16
TEMPERATURE (°C)		24.0	13.0 – 17.0	8.0 – 13.5	25.5	15.0 – 20.0	15.0 – 22.5	12.0 – 19.0	14.0 – 20.0
DISS. OXYGEN (mg/ℓ)		9.6	9.8 – 10.0	9.6 – 11.3	7.6	4.2 – 8.8	1.6 – 7.3	7.8 – 10.6	7.7 – 9.1
5-DAY BOD (mg/ℓ)		< 1	< 1 – 2	< 1 – 2	2	2 – 4	2 – 5	1 – 4	< 1 – 2
TOT. ORG. CARBON (mg/ℓ)		1.1	–	1.0	4.2	–	2.1	5.4	4.0
COLIFORM (MPN/100mℓ)	Total [1]	< 20	20 – 790	20 – 16000	200	< 200 – 16000	80 – 2400	< 200 – 1300	4900 – 24000
	Fecal [1]	< 20	< 20	< 20 – < 200	< 200	< 20 – 200	20 – < 200	120 – 200	1100 – 5400
NITROGEN (mg/ℓ – N)	Kjeldahl	< 0.1	0.1	< 0.1 – 0.2	0.2 – 0.3	0.2 – 0.6	0.1 – 0.7	< 0.1 – 0.8	0.4 – 0.7
	Nitrate	0.06	0.06 – 0.08	0.04 – 0.09	0.01	0.01	< 0.005 – 0.05	0.01 – 0.62	0.38 – 1.88
TOT. PHOSPHORUS (μg/ℓ – P)		< 20	< 20 – 40	< 20 – 80	30 – 40	20 – 50	40 – 60	30 – 180	70 – 140
TRACE METALS (mg/ℓ) [2]	Copper	0.005	< 0.005	< 0.005	< 0.005	0.005	0.005	0.005	0.005
	Iron	0.17	< 0.1	< 0.1	0.67 – 0.84	0.36 – 1.19	0.83 – 1.16	0.43 – 1.24	0.90 – 1.40
	Manganese	0.01	< 0.01 – 0.02	< 0.01	0.15 – 0.41	0.03 – 0.47	0.08 – 0.30	0.05 – 0.13	0.06 – 0.09
	Zinc	–	0.005	0.005	–	0.005	< 0.005	0.005	0.005
SUSPENDED SOLIDS (mg/ℓ)	Total	< 1	5 – 17	4 – 18	< 1 – 4	5 – 30	7 – 28	2 – 42	5 – 25
	Volatile	< 1	< 1 – 17	4 – 18	< 1 – 3	5 – 24	3 – 17	< 1 – 23	< 1 – 21
TURBIDITY (APHA Units)		4	2 – 4	1 – 2	10 – 14	4 – 8	6 – 9	9 – 34	5 – 27
COLOUR (Pt-Co Units)	Apparent	5	10	15	40	30 – 40	40 – 60	20 – 80	20 – 60
	True	< 5	10	5	5 – 10	5 – 20	10 – 20	5 – 50	10 – 50
pH		6.5	6.4 – 7.1	6.7 – 7.1	7.2	6.9 – 7.3	6.9 – 7.1	7.8 – 7.9	7.5 – 7.8
TOTAL ALKALINITY (mg/ℓ as $CaCO_3$)		3	2 – 3	4 – 9	49 – 54	20 – 46	47 – 72	41 – 83	73 – 89
TOTAL HARDNESS (mg/ℓ as $CaCO_3$)		4	< 1 – 3	< 1 – 10	39 – 56	22 – 49	52 – 72	28 – 93	95 – 101
DISS. SOLIDS (mg/ℓ)		39	6 – 48	< 1 – 44	80 – 100	33 – 67	72 – 140	45 – 176	58 – 188
CONDUCTANCE (μmho)		11	9 – 13	15 – 28	113 – 124	59 – 110	118 – 150	74 – 217	223 – 243
CHLORIDE (mg/ℓ)		< 10	< 10	< 10	< 10	< 10	< 10	≤ 10	12 – 14

[1] Where range is recorded, parenthesis ( ) indicate corresponding total and fecal coliform readings.

[2] Concentrations found were below the detectable level in mg/ℓ, for the following trace metals: Cd (0.003), Co (0.020), Pb (0.060), Mo (0.030), Ni (0.020), Ag (0.002).

TABLE 6 (cont'd) :

WATER QUALITY PARAMETER		STATION NUMBER AND LOCATION							
		Vedder Canal		Chilliwack River	Chilliwack Creek	Elk Creek	Harrison River	Chehalis River	Silverhope Creek
		T17	T18	T19	T20	T21	T22	T23	T24
TEMPERATURE (°C)		14.0	–	11.0 – 13.5	20.0	10.0 – 13.0	–	11.0 – 14.0	9.0
DISS. OXYGEN (mg/ℓ)		10.0	–	10.0 – 10.7	0.0 – 7.7	10.3 – 11.0	9.7 – 9.9	10.4 – 10.9	11.3
5-DAY BOD (mg/ℓ)		< 1	–	< 1	3.5 – 6.0	≤ 1	< 1	≤ 1	< 1
TOT. ORG. CARBON (mg/ℓ)		–	3.1	0.5	5.4	–	0.7	–	–
COLIFORM (MPN/100mℓ)	Total [1]	< 200	–	20 – 330	5400 – 160000	< 20 – 490	< 20	< 20 – 330	170
	Fecal [1]	< 200	–	<20 – <50	80 – 1300	< 20 490	<20	≤ 20	20
NITROGEN (mg/ℓ – N)	Kjeldahl	≤ 0.1	< 0.1	< 0.1 – 0.2	0.5 – 0.9	< 0.1 – 0.2	≤ 0.1	< 0.1 – 0.2	< 0.1
	Nitrate	0.03 – 0.05	0.04	0.03 – 0.05	0.04 – 2.38	0.10 – 0.17	0.03	0.05	0.02
TOT. PHOSPHORUS (μg/ℓ – P)		< 20 – 30	30	20 – 40	100 – 140	< 20 – 40	–	< 20 – 90	< 20
TRACE METALS (mg/ℓ) [2]	Copper	< 0.005	<0.005	<0.005	0.005	0.005	0.005	0.005 – 0.015	<0.005
	Iron	0.20 – 0.30	0.10	0.10 – 0.20	1.20 – 1.60	< 0.10	< 0.10	<0.10	<0.10
	Manganese	0.01 – 0.04	0.01	≤ 0.01	0.11 – 0.17	≤ 0.01	<0.01	<0.01	≤ 0.01
	Zinc	–	–	0.005	<0.005	0.010	–	<0.005	0.010
SUSPENDED SOLIDS (mg/ℓ)	Total	< 1 – 11	13	< 1 – 40	5 – 25	2 – 22	8 – 15	< 1 – 16	< 1
	Volatile	< 1 – 7	9	< 1 – 23	5 – 25	2 – 18	2 – 15	< 1 – 16	< 1
TURBIDITY (APHA Units)		6 – 17	2	3 – 52	7 – 21	1 – 8	2 – 3	1 – 4	1 – 10
COLOUR (Pt-Co Units)	Apparent	20	10	5 – 10	40 – 80	5 – 10	5	5	< 5
	True	5	10	< 5 – 10	5 – 50	5 – 10	5	5	< 5
pH		7.3 – 7.9	7.6	7.2 – 7.9	6.7 – 7.1	7.7 – 8.0	–	6.9 – 7.2	7.6
TOTAL ALKALINITY (mg/ℓ as $CaCO_3$)		18 – 36	11	15 – 20	54 – 85	29 – 76	13	5	12 – 13
TOTAL HARDNESS (mg/ℓ as $CaCO_3$)		20 – 23	26	9 – 25	88 – 99	59 – 111	14 – 15	< 1 – 7	6 – 14
DISS. SOLIDS (mg/ℓ)		38 – 63	93	18 – 84	51 – 138	12 – 136	< 1 – 26	2 – 78	47 – 51
CONDUCTANCE (μmho)		45 – 91	65	43 – 50	204 – 229	134 – 222	40	16 – 57	28 – 32
CHLORIDE (mg/ℓ)		< 10	–	< 10	<10 – 12	< 10	–	< 10	< 10

[1] Where range is recorded, parenthesis ( ) indicate corresponding total and fecal coliform readings.

[2] Concentrations found were below the detectable level in mg/ℓ, for the following trace metals : Cd (0.003), Co (0.020), Pb (0.060), Mo (0.030), Ni (0.020), Ag (0.002).

TABLE 7 : FRASER RIVER SEDIMENT CHARACTERISTICS

QUALITY PARAMETER		STATION NUMBER AND LOCATION																		
		Middle Arm	North Arm					Canoe Pass	Main Arm	Main Stem										
		1	2	3	4	5	6	7	10	11	12	13	14	15	16	17	18	19	20	21
VOLATILE CONTENT(%)		0.21	0.42	0.25	0.53	0.23	0.28	0.29	0.27	0.36	0.16	0.19	0.30	0.30	0.28	0.60	0.33	0.26	0.26	0.36
KJEL-N (mg-N/Kg)		150	220	210	220	120	185	145	160	130	120	125	160	145	110	730	230	140	135	225
TOT-P (mg-P/Kg)		1250	1260	1140	1140	1260	1190	1080	1000	1120	1200	920	1100	800	1260	3150	1700	1420	1320	1200
TRACE METALS mg/Kg	Co	20	20	20	20	25	20	27	30	20	10	25	30	20	30	25	20	20	35	20
	** Cr	80	200	125	150	400	800	200-1500	300	2000	125	800	200	150	700	200	150	200	700	150
	Cu	20	35	10	25	20	20	20	40	20	20	30	30	30	40	50	100	40	50	30
	Fe *	49	70	56	49	105	70	125	70	70	49	70	56	49	140	70	56	70	>140	70
	Mn	200	500	200	300	600	500	750	300	500	400	800	400	200	1000	300	200	300	1000	500
	Mo	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Ni	100	125	60	60	100	100	150	200	30	40	100	100	60	150	100	70	100	200	100
	Pb	5	12	5	10	8	10	8	7	7	7	7	10	7	4	10	10	10	6	5

TABLE 8 : TRIBUTARY SEDIMENT CHARACTERISTICS

QUALITY PARAMETER		STATION NUMBER AND LOCATION													
		Brunette	Coquitlam	Pitt	Alouette	Kanaka	Salmon		Nicomen			Sumas	Vedder		Chilliwack River
		T1	T3	T4	T5	T6	T7	T8	T12	T13	T14	T15	T17	T18	T19
VOLATILE CONTENT(%)		0.93	0.36	0.95	3.48	1.54	0.64	0.37	0.58	0.40	1.10	0.73	1.00	0.72	0.54
KJEL-N (mg-N/Kg)		430	120	850	5800	2465	480	165	930	200	2100	1050	1750	865	295
TOT-P (mg-P/Kg)		–	700	2500	2400	2000	1560	800	2000	1120	1920	2400	1145	2300	1400
TRACE METALS mg/Kg	Co	10	20	30	20	25	30	20	30	30	20	20	20	15	10
	** Cr	70	125	180	165	180	200	180	200	100	125	150	125	90	60
	Cu	40	10	40	50	50	50	10	50	50	50	50	50	40	40
	Fe *	49	70	70	70	70	105	70	70	70	>140	56	56	56	42
	Mn	500	600	350	300	700	700	700	500	800	500	200	400	200	400
	Mo	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Ni	20	30	100	60	80	125	40	100	50	50	70	50	40	25
	Pb	70	7	12	19	40	18	7	10	10	15	15	10	7	8

* Concentrations of Iron are in g/Kg. ** Concentrations of Silver < 1mg/Kg in all samples.

VI. DISCUSSION OF RESULTS

Because of the breadth of the sampling program and the complexity of the Lower Fraser system, conclusions regarding existing water quality in the Lower Fraser basin must be approached with caution. Collection of representative base line data was complicated by the occurrence of unusually high runoff from both the Upper Fraser watershed and several tributary basins. The summer sampling program was initiated in early July, 1972, at a time when the Fraser River flood waters were just beginning to recede, and in order to offset partially the likelihood of quality variability due to variations in background load as well as in the dilution available for effluent and tributary waters, sampling of Fraser River water was conducted largely in the month of August. Tributary waters were sampled over the entire two month period. Flow variation at Hope during the two month sampling period was from 111,000 to 320,000 cfs (24).

Precipitation variations in the study area may affect water quality through direct wash of atmospheric materials, as well as from land wash via natural and engineered drainage systems. However, no attempt was made to correlate precipitation with water quality at this point in the study.

Advective and dispersive characteristics in the estuary zone of the Lower Fraser are affected by tidal factors, river flows and channel geometry, as well as local mixing effects. Again, no attempt was made at this stage in the program to correlate quality data with channel section, localized mixing or tide.

Within the scope of the summer sampling program some general observations and comparisons of water quality in the Lower Fraser system can be made. In keeping with the general format of this report, the data are discussed in three sections: The first section deals with water quality in the Fraser River, the second with water quality in the tributaries, and the third with sediment characteristics in both the Fraser and its tributaries.

Fraser River Water Quality

Comparison of the summer data (Table 5) with that from the historical review (Table 1) shows that for the months of July and August the 1972 data are generally within the range of the historical data (or of higher quality) for those parameters and reaches where comparative data are available (temperature, DO, BOD, total coliform, nitrate-nitrogen, iron, suspended solids, total hardness and total alkalinity). Turbidity, colour and dissolved solids levels observed in 1972 were slightly higher in some reaches. The summer data supplements the historical review in several important aspects, including the addition of TOC, fecal coliform, Kjeldahl-nitrogen, total phosphorus, cadmium, cobalt, lead, molybdenum, nickel, and silver data for these months, and the expansion of temperature, DO, BOD, total coliform, nitrate-nitrogen, copper, iron, manganese, zinc, suspended solids, turbidity, colour, pH, hardness, alkalinity, dissolved solids, conductance, and chloride measurements to those reaches not previously sampled.

At this stage it would be premature to draw definite conclusions regarding existing water quality in the Lower Fraser River. However, based on the summer work and the historical review the following summary of existing water quality is possible. Additional work is needed to establish more firmly the representativeness of the data collected, to expand data collection to those months and to those parameters not yet investigated, and to define cause-effect relationships affecting water quality in the system.

1. For the most part dissolved oxygen levels in the Lower Fraser are close to saturation, with the possible exception of the North Arm/ Middle Arm reaches, where evidence of localized levels of low DO have been reported. The cause of these lower DO levels has not been ascertained directly. Data for BOD is generally consistent with the dissolved oxygen data reported, although BOD information is not as prevalent as information on dissolved oxygen levels.

2. Data on TOC levels is generally sparse. Since TOC concentrations include organics which have traditionally been measured as BOD, as well as those which are generally considered not to exert a BOD, more information is needed to define clearly the nature of the organic materials present so that receiving water effects can be delineated.

3. Levels of coliform in the Lower Fraser are highly variable. It is likely that this is due to the variability in the contributory sources, as well as to the variability in background load and die-off relationships within the river-estuary system. More information is needed to delineate the nature of bacteriological sources, as well as to define cause-effect relationships in the system.

4. Nutrient data is generally sparse, although information on nitrate levels is available for most months and in most reaches from both the historical review and the summer data. Kjeldahl nitrogen and total phosphorus levels are available for the high runoff season from the summer work. Since the significance of nutrient levels present in the river will depend on the nature of the water quality effect studied, interpretation of the results obtained to date has not been made.

5. Some stations exhibited higher trace metal concentrations than those levels generally present in the ambient water. In particular, the Middle Arm station (No. 1) exhibited higher concentrations of copper and zinc, and the Iona Island station (No. 2) exhibited a slightly higher concentration of zinc than other stations on the Fraser River. Whether these concentrations are representative of quality at these sites or whether they represent a significant difference in quality compared to other stations on the river has not been established at this stage.

Tributary Water Quality

In order to compare quality in tributary waters the summary presented in Table 9 was prepared. This tabulation ranks each tributary in terms of 13 quality parameters measured during the summer sampling program. Ranks for trace metals other than iron and manganese are not included, since concentration levels were either below detectable limits or

relatively consistent between tributaries (See Table 6). The ranks assigned vary from 1, representing the highest quality based on the summer data, to 17, representing the lowest quality. Where possible, ranks are based on data at sites closest to the mouth of the tributary, thus providing an integration of water quality for the basin. Although the limited amount of data on which to base a rank is recognized as a limitation to Table 9, especially with regard to seasonal variations, the tabulation provides a convenient focal point for reviewing tributary waters. The summer work was especially important in this respect because of the general lack of readily available historical data on tributary quality (See Table 1).

The summary developed in Table 9 shows that 5 tributaries -- Chilliwack Creek, Salmon River, Sumas River, Brunette River and Nicomen Slough -- are consistently in the lowest rankings for the 13 parameters identified. The Alouette River, Kanaka Creek, Elk Creek and Norrish Creek tend to fall mid-range in the ranking, although there are several exceptions. The other tributaries vary in rank depending on the nature of the parameter measured; a number of ranks, e.g. dissolved oxygen ranks 1-10, are identical, as discussed in the footnotes to Table 9.

In addition to the tributary ranking developed in Table 9, the following observations on tributary quality can be made:

1. The five tributary waters cited above as exhibiting consistently lower quality had peak BOD concentrations ranging from 4 to >22 mg/l, minimum DO levels varying from 0.0 to 7.8 mg/l (0 - 84% saturation), and TOC levels of 3.1 to 5.4 mg/l, indicating a high level of organic enrichment.

2. Total and fecal coliform levels were highly variable. As with the data for the Fraser River, this is undoubtedly due to variability in the nature of contributory sources as well as to variability in bank runoff, background load and die-off relationships in the tributary waters.

3. Peak nutrient levels in the five tributaries cited above varied from 0.6 to 1.7 mg/l of Kjeldahl nitrogen, from 0.05 to 2.9 mg/l nitrate nitrogen, and 60 to 260 μg/l total phosphorus. Peak nutrient levels at the Alouette, Kanaka, Elk and Norrish sites varied from 0.2 to 0.4 mg/l of Kjeldahl nitrogen, 0.01 to 0.2 mg/l nitrate nitrogen, and 40 to 80 μg/l of total phosphorus. The remaining tributaries varied in peak nutrient concentration from ≤0.1 to 0.2 mg/l Kjeldahl nitrogen, from 0.02 to 0.15 mg/l nitrate nitrogen, and from ≤20 to 40 μg/l total phosphorus.

4. Elevated iron and manganese levels were observed in several of the samples from basins associated with urban and agricultural land use practices. Copper and zinc levels were generally ≤0.005 to 0.01 mg/l in all basins, although slightly higher levels were measured at a Brunette River station (T2) and at the Chehalis River station (T23).

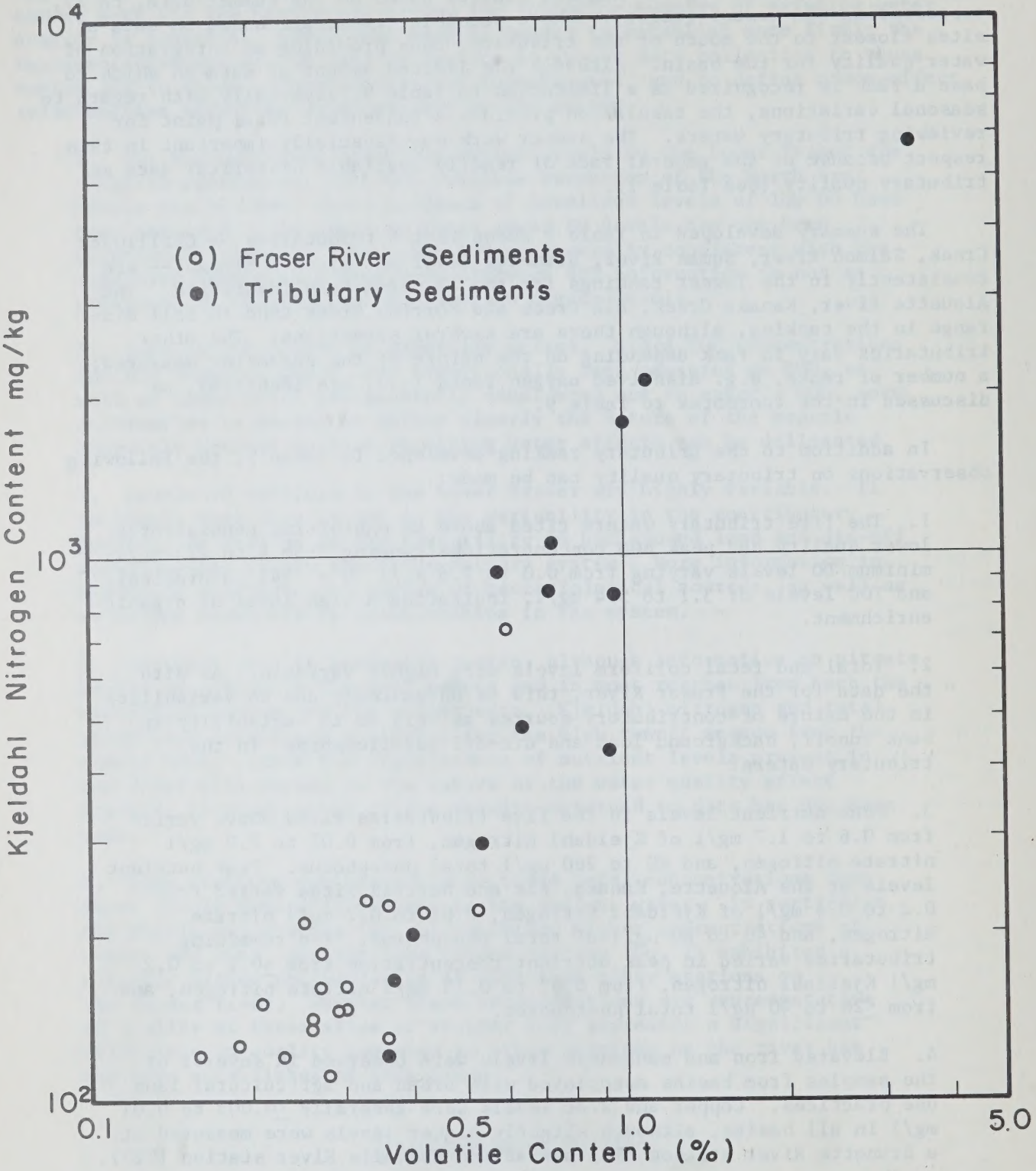


FIGURE 2: KJELDAHL NITROGEN AND VOLATILE CONTENT OF SEDIMENTS.

Sediment Characteristics

Because of the limited number of sediment samples obtained in the summer survey and the general lack of historical data on sediment quality characteristics, interpretation and discussion of the summer data must be limited. However, the following points can be noted:

1. Volatile content and Kjeldahl nitrogen content in the tributary sediments is generally higher than in the Fraser River sediments, as shown on the correlation plot of Figure 2. Since particle-size classifications were not made, it is not possible at this stage to relate the levels obtained to cause-effect relationships operating in the Lower Fraser or in its tributary waters.

2. Phosphorus levels in the Fraser River sediments collected are generally consistent at 1100 to 1200 mg/Kg, although some samples analyzed exhibited levels both above and below these values. The majority of tributary sites sampled yielded sediment phosphorus levels higher than those in the Lower Fraser. Whether this is due to variations in sedimentation patterns, to differing water usage or to a combination of both is not known at this stage.

3. Several Fraser River and tributary sediment samples exhibited trace metal levels higher than those experienced at other stations, including chromium from Canoe Pass (Sta. 7) and from the Main Stem at Pattullo Bridge (Sta. 11), copper from Station 18, and manganese from Stations 16 and 20. Lead levels in sediments from the Brunette River and Kanaka Creek sites also appear to be higher than those evident in samples from either the Fraser River or other tributary stations.

TABLE 9: COMPARISON OF TRIBUTARY WATER QUALITY

RANK [1]	WATER QUALITY PARAMETER												
	DO [2]	BOD [3]	TOC	COLIFORM		TOT. NITROGEN [4]	TOT. PHOSPH.	IRON [5]	MANGANESE [6]	TOT. S. SOLIDS	TURBIDITY	TRUE COLOUR [7]	DISS. SOLIDS
				Total	Fecal								
1	Coquitlam	Pitt	Chilliwack River	Harrison	Harrison	Silverhope	Silverhope	Norrish	Pitt	Silverhope	Norrish	Pitt	Kanaka
2	Pitt	Vedder	Harrison	Silverhope	Stave	Vedder	Pitt	Elk	Norrish	Pitt	Harrison	Norrish	Pitt
3	Stave	Chilliwack River	Norrish	Vedder	Chehalis	Harrison	Vedder	Harrison	Chilliwack River	Vedder	Stave	Harrison	Harrison
4	Norrish	Harrison	Pitt	Kanaka	Silverhope	Pitt	Coquitlam	Chehalis	Elk	Harrison	Chehalis	Chehalis	Norrish
5	Vedder	Silverhope	Stave	Chilliwack River	Chilliwack River	Stave	Stave	Silverhope	Harrison	Chehalis	Coquitlam	Silverhope	Stave
6	Chilliwack River	Elk	Coquitlam	Chehalis	Kanaka	Norrish	Chilliwack River	Stave	Chehalis	Alouette	Elk	Stave	Silverhope
7	Elk	Chehalis	Salmon	Elk	Alouette	Chilliwack River	Elk	Chilliwack River	Silverhope	Stave	Alouette	Vedder	Chehalis
8	Harrison	Coquitlam	Vedder	Coquitlam	Norrish	Chehalis	Brunette	Coquitlam	Coquitlam	Norrish	Silverhope	Chilliwack River	Chilliwack River
9	Chehalis	Kanaka	Nicomen	Stave	Vedder	Coquitlam	Alouette	Pitt	Stave	Kanaka	Nicomen	Elk	Vedder
10	Silverhope	Stave	Brunette	Alouette	Nicomen	Elk	Nicomen	Vedder	Alouette	Elk	Pitt	Coquitlam	Alouette
11	Brunette	Norrish	Sumas	Salmon	Coquitlam	Kanaka	Norrish	Brunette	Vedder	Chilliwack Creek	Vedder	Kanaka	Coquitlam
12	Sumas	Alouette	Chilliwack Creek	Norrish	Elk	Alouette	Chehalis	Alouette	Sumas	Brunette	Brunette	Nicomen	Elk
13	Alouette	Sumas	–	Nicomen	Brunette	Nicomen	Chilliwack Creek	Kanaka	Kanaka	Coquitlam	Chilliwack Creek	Alouette	Chilliwack Creek
14	Nicomen	Nicomen	–	Brunette	Chilliwack Creek	Brunette	Sumas	Nicomen	Chilliwack Creek	Nicomen	Kanaka	Sumas	Nicomen
15	Salmon	Chilliwack Creek	–	Sumas	Salmon	Sumas	Salmon	Sumas	Brunette	Chilliwack Creek	Sumas	Chilliwack Creek	Sumas
16	Chilliwack Creek	Brunette	–	Chilliwack Creek	Sumas	Chilliwack Creek	–	Chilliwack Creek	Salmon	Sumas	Salmon	Brunette	Brunette
17	–	Salmon	–	–	–	Salmon	–	Salmon	Nicomen	Salmon	Chilliwack River	Salmon	Salmon

NOTES :

1) Rank given is from highest quality (1) to lowest quality (17), based on the summer data.

2) D.O. ranked according to lowest % saturation value detected, other parameters ranked by peak concentration detected.
D.O. ranks 1 – 10 are all ≥ 95% saturation.

3) Ranks 1 – 7 identical at ≤ 1mg/ℓ.

4) Total Nitrogen = Kjeldahl plus nitrate nitrogen (nitrite data were not obtained).

5) Ranks 1 – 5 identical at < 0.1mg/ℓ

6) Ranks 1 – 7 identical at ≤ 0.01mg/ℓ.

7) Ranks 1 – 5 identical at ≤ 5 colour units.

REFERENCES

1. Goldie, C.A., "Pollution and the Fraser - Report I." Pollution Control Board, Department of Lands, Forests and Water Resources, Province of British Columbia, Victoria (April, 1967).

2. "Water Quality in the Fraser - Thompson River System of British Columbia." B.C. Research Council, Vancouver (April, 1952).

3. Thomas, J.F.J., "Industrial Water Resources of Canada - Water Survey Report No. 6: Fraser River Drainage Basin, 1950-51." Department of Mines and Technical Surveys, Publication No. 842, Ottawa (1954).

4. "Fraser River Water Quality at Marpole, November 1st and 2nd, 1955." B.C. Research Council, Vancouver (November, 1955).

5. Unpublished Data. Public Health Branch, Province of British Columbia, Victoria (1959-1965).

6. Unpublished Data. Greater Vancouver Sewerage and Drainage District, Vancouver (1957-1966).

7. Servizi, J.A. and Burkhalter, R.A., "Selected Measurements of Water Quality and Bottom-Dwelling Organisms of the Fraser River System, 1963-1968." International Pacific Salmon Fisheries Commission, New Westminster, B.C. (1970).

8. Unpublished Data. Fisheries Service, Department of the Environment, Vancouver (1969-1971).

9. "Water Quality Survey of the Lower Fraser River." B.C. Research Council, November 1971. In Provincial Power Study, B.C. Energy Board, Vol. 3, Appendix I-A, Montreal Engineering Co., Ltd. (April, 1972).

10. Rusch, W.A., "A Computer Simulation of Fecal Coliforms in the Fraser Estuary." Thesis submitted in partial fulfillment of the requirements for Master of Applied Science, Department of Civil Engineering, University of British Columbia (September, 1972).

11. Unpublished Data. Greater Vancouver Sewerage and Drainage District, Vancouver (1968-1970).

12. "Sediment Data for Canadian Rivers - Fraser River at Hope,....Agassiz, ...Mission,....Port Mann." Water Survey of Canada, Ottawa (1965-1968).

13. National Water Quality Data Bank (NAQUADAT). "Water Quality on the Fraser River for the Period 1960-1972, Fraser River at Hope and Fraser River at Mission City." Water Quality Division, Inland Waters Branch, Department of the Environment, Ottawa (January 27, 1973).

14. "Standard Methods for the Examination of Water and Wastewater." A.P.H.A., A.W.W.A., and W.P.C.F., 13th edition, (1971).

15. Menzel, D.W. and Vaccaro, R.F. "The Measurement of Dissolved Organic and Particulate Carbon in Seawater." Limnol. and Oceanogr. 9. 138-142 (1964).

16. Strickland, J.D.H. and Parsons, T.R. "A Practical Handbook for Seawater Analysis." Bulletin 167 Fisheries Research Board of Canada, Ottawa (1968).

17. Technicon AAII Industrial Method No. 100-70W (January 1971), and Standard Methods (14).

18. Technicon AAII Industrial Method No. 30-59A, and Standard Methods (14).

19. Adapted from Technicon AAII Industrial Method No. 155-71W (Nov. 1971) Glucose was used instead of ascorbate as the reducing agent.

20. Delavault, R.E. Geological Sciences, U.B.C. Personal communication (1972).

21. Fletcher, W.K. Geological Sciences, U.B.C. Personal communication (1972).

22. Bremner, J.M. in "Methods of Soil Analysis". C.A. Black (ed.) American Society of Agronomy (1965).

23. Olsen and Dean in "Methods of Soil Analysis". C.A. Black (ed.) American Society of Agronomy (1965).

24. "Surface Water Data - British Columbia." Water Survey of Canada, Ottawa (1949-1972).

BIBLIOGRAPHY

1. Fraser River Estuary, Burrard Inlet, Howe Sound and Malaspina Strait Physical and Chemical Oceanographic Data, 1957-1966. Manuscript Report No. 939, Fisheries Research Board of Canada, Biological Station, Nanaimo, British Columbia, (February 1968).

2. Fraser River Report. The Society for Pollution and Environmental Control (November 23, 1970).

3. Pretious, E.S., Downstream Sedimentation Effects of Dams on Fraser River, B.C. Water Resource Series No. 6, Department of Civil Engineering, University of British Columbia, (January 1972).

4. Sewage and Drainage of the Greater Vancouver Area, British Columbia. Vancouver and Districts Joint Sewerage and Drainage Board (September, 1953).

5. Sewerage and Drainage of the Greater Vancouver Area, British Columbia - Summary of Major Pollution Control Schemes. Greater Vancouver Sewerage and Drainage District (January 1969).

6. Study of Tidal Effects in the North Arm of the Fraser River - April 23-24, 1951. British Columbia Research Council, Vancouver (June 1951).

7. Sylvester, R.O., A Review of the Fraser River Basin with Respect to Water Quality. British Columbia Water Resources Service, Pollution Control Board (September 1965).

APPENDIX

DETAILS OF PRESERVATION TECHNIQUES AND ANALYTICAL PROCEDURES USED IN THE SUMMER SAMPLING PROGRAM

PRESERVATION AND ANALYSIS OF WATER SAMPLES

DISSOLVED OXYGEN (DO)

Samples for dissolved oxygen analysis were transferred from the Nansen-type, depth sampler to BOD bottles using standard techniques to prevent aeration. Manganous sulfate and alkaline-azide reagents were added immediately for floc formation and, after settling, were acid-fixed and stored in the dark for shipment to the laboratory. Dissolved oxygen titrations were carried out in the Department of Civil Engineering Pollution Control Laboratory within one day of sampling and preservation using Standard Methods (14) techniques.

BIOCHEMICAL OXYGEN DEMAND (BOD)

Samples for BOD analysis were stored at $4^{o}C$ following collection and during storage at the laboratory. Analyses were made at the Department of Civil Engineering Pollution Control laboratory within one day of collection. Standard Methods (14) techniques were used.

TOTAL ORGANIC CARBON (TOC)

Samples for TOC analysis were stored at $4^{o}C$ and shipped to the Department of Civil Engineering Pollution Control Laboratory for analysis. The samples were pre-filtered through precombusted glass fiber filters, and then filtered water was fixed with sodium azide and stored at $5^{o}C$ prior to analysis, while the filter pads were stored in a freezer at $-10^{o}C$.

The persulfate oxidation technique of Menzel and Vaccaro (15) was used to determine dissolved organic carbon on the filtered water. A sample volume (1 to 6 ml) containing between 2 and 24 μg of carbon was membrane filtered into a precombusted ampule and the above referenced procedure followed. The carbon dioxide liberated by the oxidation of the organic matter was determined on a non-dispersive infrared detector (Beckman Model IR-215A). Each sample was analyzed in triplicate.

Detection Limit: 2 μg of carbon (which represents 0.33 mg/l for a 6 ml sample).

Precision: 4% at the 6.5 mg/l level.

The particulate organic carbon was determined by wet oxidation with dichromate according to the method of Strickland and Parsons (16). The results are reported in terms of glucose carbon which was used as a standard. The minimum detection limit depends upon the sample size filtered. In some samples there was no significant difference from the blank when a sample of 200 ml was used. The precision of the technique was determined as 4.7% at the 1.2 mg level.

Total Organic Carbon levels recorded in the data tabulations were obtained by summation of the dissolved and particulate organic carbon values.

TOTAL AND FECAL COLIFORM

Total and fecal coliform analyses were conducted in the Pollution Control Laboratory of the Department of Civil Engineering on water samples stored at 4°C after collection. All samples were analyzed within one day after collection. The multiple-tube fermentation technique was used, as outlined in Standard Methods (14), yielding results expressed as Most Probable Number (MPN) of coliform organisms/100 ml of sample.

NITROGEN AND PHOSPHORUS

Samples for nitrogen and phosphorus determinations were field-stored at 4°C prior to analysis at the laboratory of the Department of Agricultural Engineering. Analyses for nitrate-nitrogen were made within 3 weeks of collection, while Kjeldahl-nitrogen and total phosphorus determinations were delayed up to two months. Samples were kept at 4°C in the laboratory prior to analysis.

Kjeldahl-nitrogen, nitrate and total phosphorus analyses were performed using a Technicon Industrial Autoanalyzer II and the following analytical procedures:

(1) Nitrate-nitrogen. The automated procedure (17) for nitrate-nitrogen consisted of the reduction of nitrate to nitrite using a copper-cadmium reduction column followed by the reaction of nitrite with sulphanilamide to form a diazo compound which couples with N-1-naphthalene diamine dihydrochloride to form a reddish purple azo dye.

Detection Limit: 0.005-mg/l NO_3-N

*Precision: Determined as 1.5 percent at 0.5 mg/l NO_3-N.

(2) Kjeldahl-nitrogen. The automated procedure (18) for Kjeldahl-nitrogen consisted of digestion of organic material using the Technicon continuous digestor followed by quantitative determination of the ammonia produced utilizing the Berthelot Reaction in which a blue coloured compound related to indophenol is formed when ammonia reacts with sodium phenoxide and sodium hypochlorite.

Detection Limit: 0.05 mg/l-N

Precision: Determined as 5.8 percent at 1.0 mg/l-N.

---

* All nutrient precision values are expressed as relative standard deviation as suggested by APHA Standard Methods, 13th ed., page 24, 1971 (14).

(3) Total Phosphorus. Total phosphorus was measured by automated digestion (19) of the sample with a mixture of sulfuric and perchloric acids, using a selenium catalyst. The phosphate in the digest is reacted with ammonium molybdate and the phosphomolybdate complex is reduced to molybdenum blue in a 95°C heating bath. The molybdenum blue forms a complex with antimony which has an absorption peak at 880 nm. Silica at 100 mg/l does not interfere.

Detection Limit: 20 μg/l-P

Precision: Determined as 2.3 percent at the 200 μg/l-P level.

TRACE METALS

Samples for trace metal analysis were collected and stored in acid-washed (50% HCl) polyethylene bottles, dual rinsed with distilled water to minimize possibility of sample contamination. Samples were field preserved with concentrated HCl to pH 2. Analytical work was conducted in the laboratory of the Department of Geological Sciences. Procedural details are outlined below:

(1) Molybdenum. Levels of molybdenum were determined by reaction with thiocyanate in acid solution under reducing conditions (stannous chloride) to form a complex which is yellow to orange in colour, followed by visual comparison to a series of standards (20). High concentrations of iron or coloured compounds can interfere.

Detection limit: 30 μg/l

Precision: Not determined, as concentrations were at or below detection limit.

(2) Other Metals. Levels of silver, cadmium, cobalt, copper, iron, manganese, nickel, lead and zinc were determined by transferring a 250 or 500 ml sample to an acid washed beaker containing 3 ml of concentrated hydrochloric acid. The solution was evaporated to 15-20 ml, diluted to 25 ml, and analyzed on an atomic absorption spectrophotometer (21). It was necessary to make a background correction for Co, Ni, Pb, Cd, and Ag.

Detection Limits and Precision:

Element	Detection Limit (μg/l)	Precision*
Ag	2	-
Cd	3	-
Co	20	-
Cu	3	48
Fe	100	21
Mn	8	8
Ni	20	-
Pb	60	-
Zn	4	67

* Precision expressed as per cent at 95% confidence interval. Elements not having precision values were below detectable concentrations in all samples. High values for four elements shown are due to large number of samples with concentrations near the detection limit.

GENERAL CHEMICAL PARAMETERS

Samples for determination of the general parameters discussed below were stored at 4°C prior to analysis. Analytical work was conducted in the Pollution Control Laboratory of the Department of Civil Engineering within 2 to 3 days of collection.

(1) Colour measurements were made using a Hellige Aqua tester.
(2) Turbidity levels were measured using a Hellige turbidimeter.
(3) Chloride determinations were made with a Corning chloride ion probe, using a double junction reference electrode.
(4) All other analyses were conducted according to Standard Methods (14) techniques.

ANALYSIS OF SEDIMENT SAMPLES

ORGANIC CONTENT

Organic content (volatile dry weight) of the sediment samples collected was determined at the Pollution Control Laboratory of the Department of Civil Engineering using Standard Methods techniques (14).

NITROGEN AND PHOSPHORUS

Sediment samples for nutrient determinations were dried at 80°C and stored at room temperature prior to analysis at the laboratory of the Department of Agricultural Engineering.

Kjeldahl-nitrogen was determined by the classical Kjeldahl procedure (22) in which the sample is digested for 2 hours with concentrated H_2SO_4 using a selenium catalyst. The ammonia released during the digestion is distilled and titrated with standard H_2SO_4. These analyses were done in duplicate due to the heterogenous nature of the sediments.

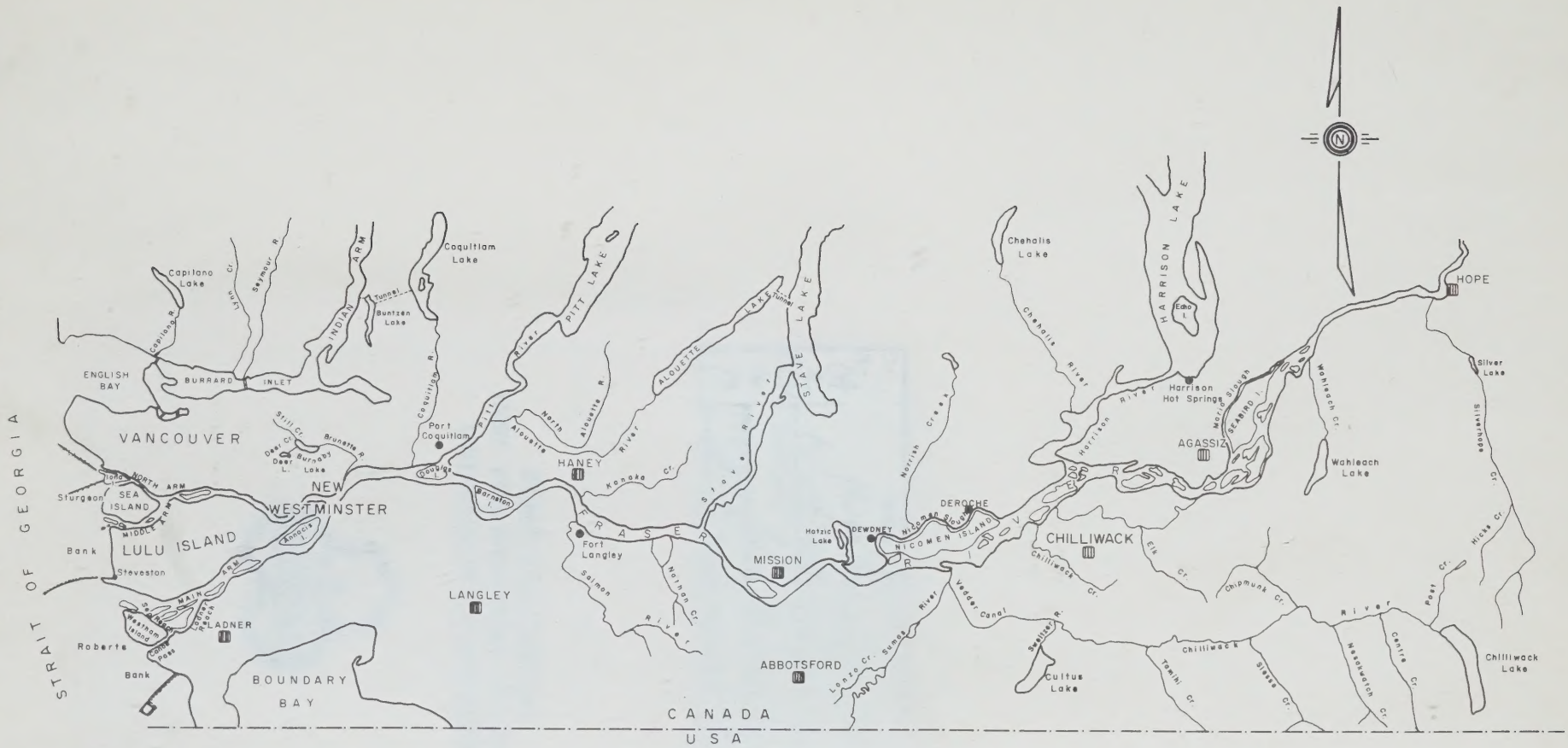
Total phosphorus was determined by extraction of the pre-dried sample with concentrated HCl following ignition for one hour at 240°C (23). The extracts were analyzed for phosphorus on a Technicon Autoanalyzer II, using complexation with acid molybdate and reduction to molybdenum blue with stannous chloride. The absorbance of the resulting solution was measured at 660 nm.

TRACE METALS

Sediment samples were analyzed for trace metals in the laboratory of the Department of Geological Sciences. Samples were pre-dried at 95°C and then sieved through an 80-mesh screen. The sieved sample was ignited at 550°C for three hours and 0.1 grams of the ash mixed with an equal weight of graphite containing an indium standard. The samples were analyzed by a semi-quantitative DC-arc spectrographic procedure (21) for 9 elements, namely Ag, Co, Cr, Cu, Fe, Mn, Mo, Ni, and Pb.

Detection Limit:

Element	Detection Limit (mg/Kg)
Ag	1
Co	5
Cr	1
Cu	10
Fe (as Fe_2O_3)	0.1%
Mn	1
Mo	2
Ni	5
Pb	2



Scale : 1" = 6 Miles Approx.

5 0 5 10 Miles

5 0 5 10 Kilometres

Dc
No
CA
2
BCU
16
73

rate Author:
U.B.C.
Westwater Res. Centre.
Series: Tech. Rept. # 2
Title: A Preliminary Water

RESOURCE CENTRE
INST. FOR ENVIORN'L. STUDIES
UNIVERSITY OF TORONTO